sat-nms ACU-ODM

Antenna Control Unit - Outdoor Module

User Manual

Version 4.3 / 2012-11-08

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1 Introduction

The ***sat-nms*** Antenna Control Unit is an antenna controller / positioner with optional satellite tracking support. It may be operated as a standalone unit or in conjunction of the ***sat-nms*** ACU-IDU, a PC based indoor unit which offers extended tracking capabilities and a full featured visualization interface.

The ***sat-nms***-ACU is available as:

- ***sat-nms*** ACU-ODM: only the core-module integrated in a compact case prepared for mounting on a 35mm DIN rail
- ***sat-nms***-ACU-ODU: complete antenna controller system for AC- or DC-Motors integrated in an outdoor cabinet that could be mounted directly to the antenna. By mounting a ***sat-nms*** LBRX beacon receiver into this cabinet, you have a complete antenna tracking system in a compact cabinet directly at your antenna.
- ***sat-nms***-ACU-RMU: complete antenna controller system for AC-Motors integrated in a 6RU 19inch rack mount case for indoor use
- ***sat-nms***-ACU19: complete antenna controller system for DC-Motors integrated in a 1RU 19inch rack mount case for indoor use

For detailed description please refer to the ***sat-nms*** documentation CD or www.satnms.com/doc

Main benefits of the ***sat-nms*** ACU are:

- The ACU outdoor unit is able to act as a standalone antenna control and tracking system without an indoor unit required.
- The ACU provides an Ethernet interface using the TCP/IP and HTTP Internet protocols. It can be controlled using any PC providing an Ethernet interface and a web browser like the Microsoft Internet Explorer. The ACU runs a web server which acts as a user interface to the antenna controller.
- The ACU is prepared to read the receive level of a ***sat-nms*** beacon receiver through the TCP/IP interface.
- The flexible interface design of the ACU enables it to control most types of motor driving antennas for geostationary satellites.

Supported motor controllers are (configurable in the field):

- **Power relays:** This simple solution is suitable for antennas using 2-speed AC motors.
- **Frequency inverters:** Speed and acceleration ramps are programmed into the inverter module with this solution.
- **Servo controllers:** Used for DC motors at small antennas.

Supported position sensors are (separate hardware interface modules for each axis:

- **Resolver Interface:** The resolver interface module contains a resolver to digital chip which does the decoding of the resolver sin/cos signals.
- **SSI Interface:** SSI is a high speed serial interface used by modern digital position encoders.
- **DC Voltage Interface:** The third position encoder interface module contains an A/D converter which is suited to measure the DC voltages produced by simple inductive angle encoders. This application is for small antennas especially in the SNG business.

The paragraphs below give a short overview to the contents of the documentation. A subset of this documentation is stored on the device itself, the complete documentation is available on the ***sat-nms*** documentation CD and at www.satnms.com.

- Safety Instructions: This chapter gives an overview about the safety precautions that have to be observed during installation, operation and maintenance.

- Unit Overview: The installation chapter gives informations about the different modules that are integrated in the ACU (not ACU-ODM and ACU19).

- Installation/Start-up: The installation chapter guides through the installation and setup of the ACU outdoor module. It describes the mechanical concept of the ACU and the assignment of the ACU's connectors. It gives you informations about the starting up procedure. Finally you learn in this chapter how to set the ACU's IP address, which is a essential precondition to operate the ACU by means of a web browser.

- Operation: The ***sat-nms*** ACU is operated using a standard web browser like the Internet-Explorer on MS Windows based computers. The user interface design is straight forward and clearly structured. Operating the ACU is mostly self-explanatory. Nevertheless, the 'Operation' chapter outlines the map of web pages which make up the ACU user interface and elaborately describe the meaning of each alterable parameter.

- Frontpanel Operation: The ***sat-nms*** ACU19 and the ***sat-nms*** ACU-RMU optionally are equipped with a frontpanel Human-Machine-Interface. This chapter describes how to use this interface.

- Remote Control: The ACU outdoor module provides a versatile remote control interface. A monitoring & control software may fully operate the ACU either through a TCP/IP network connection or through the RS232 interface of the ACU. This chapter describes the communication protocol used for remote control and lists all parameters accessible through the remote interface.

- Theory of Operation: This chapter gives a short overview how the ACU works. It also describes the different tracking algorithms and their parameters. The interaction with a beacon receiver is described as well. Knowing about the theory regarding this functions helps to find the best parameter settings for a given application.

- Specifications: At the end of the document, the specifications applicable to the ***sat-nms*** ACU are summarized in this chapter.

Support and Assistance

If you need any assistance regarding our ACU, don't hesitate to contact us. We would be pleased to help you by answering your questions.

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2 Safety Instructions

Safety

The mains shall only be connected provided with a protective earth wire. Any interruption of the protective wire, inside or outside the ***sat-nms*** ACU, is likely to make the unit dangerous. Intentional interruption is prohibited.

The unit described in this manual is designed to be used by properly-trained personnel only.

Adjustment, maintenance and repair of the exposed equipment shall be carried out only by qualified personnel who are aware of hazards involved.

Refer servicing to qualified personnel.

To prevent electrical shock, do not remove covers.

For the correct and safe use of the instrument, it is essential that both operating and servicing personnel follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

Whenever it is likely that safety protection is impaired, the unit must be made in-operative and secured against unintended operation. The appropriate servicing authority must be informed. For example, safety is likely to be impaired if the unit fails to perform the intended measurements or shows visible damage.

Ensure that the cabinet is proper connected to the protective earth conductor.

The circuit breaker, that fuses the mains for the ***sat-nms*** ACU has to switch off all phases AND the neutral wire as well.

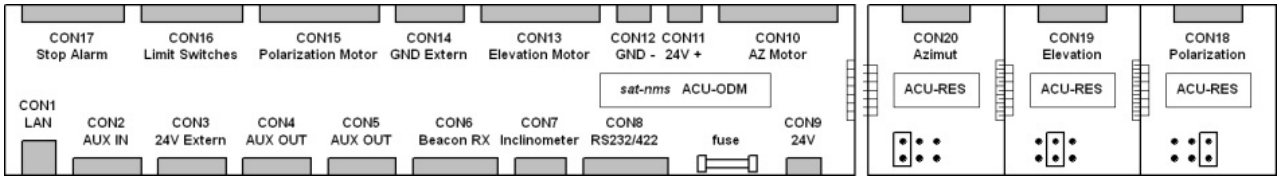
WARNINGS

- The outside of the equipment may be cleaned using a lightly dampened cloth. Do not use any cleaning liquids containing alcohol, methylated spirit or ammonia etc.
- Follow standard Electrostatic Discharge (ESD) procedures when handling the Unit.
- Apply the appropriate voltage according to the attached schematic.
- In case of switching off all the circuit breakers is still voltage available at the mains terminals!
- Only use shielded cable to connect the AZ- and EL-Motor. The other components in the cabinet might be jammed through the harmonic waves the frequency inverters inject into the motor wires.
- Use only double shielded twisted pair cables (e.g. CAT7 Ethernet cable) to connect the resolvers to the ***sat-nms*** ACU
- **Only ACU-ODU**: If the Unit is equipped with an optional air ventilation, avoid direct contact with jets of water, normal rain is no problem.

3 The *sat-nms* ACU-ODM

The ***sat-nms*** Antenna Control Unit (Outdoor Module) is an antenna controller / positioner with optional satellite tracking support. It may be operated as a stand alone unit or in conjunction of the ***sat-nms*** ACU-IDU, a PC based indoor unit which offers extended tracking capabilities and a full featured visualization interface.
The ACU-ODM is designed as a closed, compact module, prepared for mounting on a 35mm DIN rail.

Below the top viw and connector layout of the ACU outdoor module is shown. Except the network connector which is a standard 10-Base-T Ethernet socket, all connectors are Phoenix Contact Combicon plugs / clamps.



Inside, the ACU consists of a main board and two or three interface boards with the circuitry for the position sensors. These boards are different for each type of position sensor. Actually interfaces for three types of position encoders are available with the ***sat-nms*** ACU:

- resolvers
- SSI digital position encoders
- analog voltage based sensors

You have to decide at date of order which interfaces you need.

The ***sat-nms*** ACU-ODM is powered by 2 different power supplies:

- 24V ACU: for ACU internal use, especially for the core processor
- 24V EXT: for external signals, e.g. limit switches, drive signals etc.

By this a maximal reliability of the ***sat-nms*** ACU-ODM is ensured.

4 Installation

The following chapter describes how to install the ACU-ODM mechanically and electrically. Additional a detailed start-up procedure is given in this chapter.

4.1 Mechanical installation

The ACU enclosure is DIN rail mountable. Hence simply snap the module on to the rail to fix it. For plain wall mount, fix a 450 mm piece of DIN rail at the wall with at least four screws and lock the ACU on this.

4.2 Interfaces to the Antenna, Pin descriptions

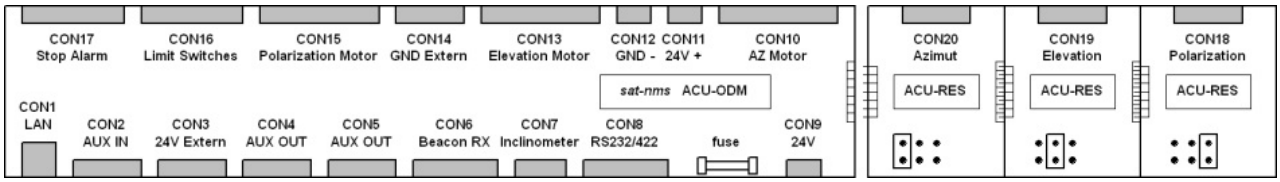
ATTENTION! Electrical installation shall be carried out only by qualified personnel who are instructed and aware of hazards of electrical shocks.

The ***sat-nms*** ACU provides a lot of input/output signals. They all are described in the following chapters. Many applications do not require all ports of the ACU to be cabled. For a minimum antenna control functionality however you should connect the following to the ACU:

- A computer via Ethernet, so you can configure the ACU through it's Web-interface
- The power supply (24V, regulated)
- The azimuth position sensor
- The azimuth motor driver circuitry
- The elevation position sensor
- The elevation motor driver circuitry

4.2.1 Connector Layout

Below the connector layout of the ACU outdoor module is shown. Except the network connector which is a standard 10-Base-T Ethernet socket, all connectors are Phoenix Contact mini Combicon plugs / clamps which are delivered together with the ***sat-nms*** ACU-ODM. Pin 1 of each connector is the rightmost if you look at the screws of the connector and the plugs are directed to you.



Inside, the ACU consists of a main board and two or three interface boards with the circuitry for the position sensors. These boards are different for each type of position sensor. Actually interfaces for three types of position encoders are available with the ***sat-nms*** ACU:

- resolvers
- SSI digital position encoders
- analog voltage based sensors

4.2.2 Pin descriptions

CON1 LAN Connector

CON1 is the Ethernet 10Base-T / RJ45 connector. Use a standard network cable to connect the ACU to an Ethernet hub. If you want to connect your computer and the ACU directly without using a hub, you need a crossover cable for this with swapped RX/TX lines.

pin	*signal*	*description*	*type*
1	TX+	default Ethernet cabling (10Base-T)	OUT
2	TX-		OUT
3	RX+		IN

4			
5			
6	RX-		IN
7			
8			

CON2 Spare Inputs

CON2 provides four opto-isolated spare inputs for the ACU. These inputs are reserved for customized versions of the ACU software, they normally are not used. There is no cabling required.

pin	*signal*	*description*	*type*
1	AUX1 IN A		IN+
2	AUX1 IN K		IN-
3	AUX2 IN A		IN+
4	AUX2 IN K		IN-
5	AUX2 IN A		IN+
6	AUX2 IN K		IN-
7	AUX2 IN A		IN+
8	AUX2 IN K		IN-

CON3 24V-EXT Distribution

CON3 provides eight clamps to the 24V-EXT rail. It has been included to simplify the external cabling.

pin	*signal*	*description*	*type*
1	24V_EXT		
2	24V_EXT		
3	24V_EXT		
4	24V_EXT		
5	24V_EXT		
6	24V_EXT		
7	24V_EXT		
8	24V_EXT		

CON4 Spare Outputs 5..8

CON4 provides four opto-isolated spare outputs for the ACU. These inputs are reserved for customized versions of the ACU software, they normally are not used. There is no cabling required.

pin	*signal*	*description*	*type*
1	AUX 5 OUT C		OUT+
2	AUX 5 OUT E		OUT-
3	AUX 6 OUT C		OUT+
4	AUX 6 OUT E		OUT-
5	AUX 7 OUT C		OUT+
6	AUX 7 OUT E		OUT-
7	AUX 8 OUT C	optional heartbeat signal	OUT+
8	AUX 8 OUT E	optional heartbeat signal	OUT-

The AUX 8 output may be configured to act as a heartbeat output. If enabled, the output switches every

1000 ms between on/off. If using this signal for an external watchdog circuit, be aware the in adaptive tracking mode delays of some seconds are possible while the acu calculates the orbital model.

CON5 Spare Outputs 1..4

CON5 provides another four opto-isolated spare outputs for the ACU. These inputs are reserved for customized versions of the ACU software, they normally are not used. There is no cabling required.

pin	*signal*	*description*	*type*
1	AUX 1 OUT C		OUT+
2	AUX 1 OUT E		OUT-
3	AUX 2 OUT C		OUT+
4	AUX 2 OUT E		OUT-
5	AUX 3 OUT C		OUT+
6	AUX 3 OUT E		OUT-
7	AUX 4 OUT C		OUT+
8	AUX 4 OUT E		OUT-

CON6 Beacon Receiver

The ACU preferably is used together with the ***sat-nms*** LBRX beacon receiver. With the ***sat-nms*** LBRX the ACU talks though TCP/IP, no additional cabling is required in this case. At CON6 the ACU provides an analog interface to third party beacon receivers.

pin	*signal*	*description*	*type*
1	Beacon Level	beacon level signal 0..10V	IN
2	GND		
3	PRESET 1 C	beacon receiver preset activation	OUT+
4	PRESET 1 E		OUT-
5	PRESET 2 C	beacon receiver preset activation	OUT+
6	PRESET 2 E		OUT-
7	PRESET 3 C	beacon receiver preset activation	OUT+
8	PRESET 3 E		OUT-
9	PRESET 4 C	beacon receiver preset activation	OUT+
10	PRESET 4 E		OUT-

CON7 Inclinometer

The ACU provides two ADC inputs to read the angle information from ratiometric inclinometers like the Schaevitz AccuStar. The standard ACU software reads this information and displays it at the 'Test' page of the software, but it does not include the nick/roll angles into the displayed antenna pointing.

pin	*signal*	*description*	*type*
1	+9V	roll reference output (9VDC)	OUT
2	VRAT X	roll measurement input	IN
3	GND	roll ground	
4	+9V	nick reference output (9VDC)	OUT
5	VRAT Y	nick measurement input	IN
6	GND	nick ground	

CON8 Serial Interfaces

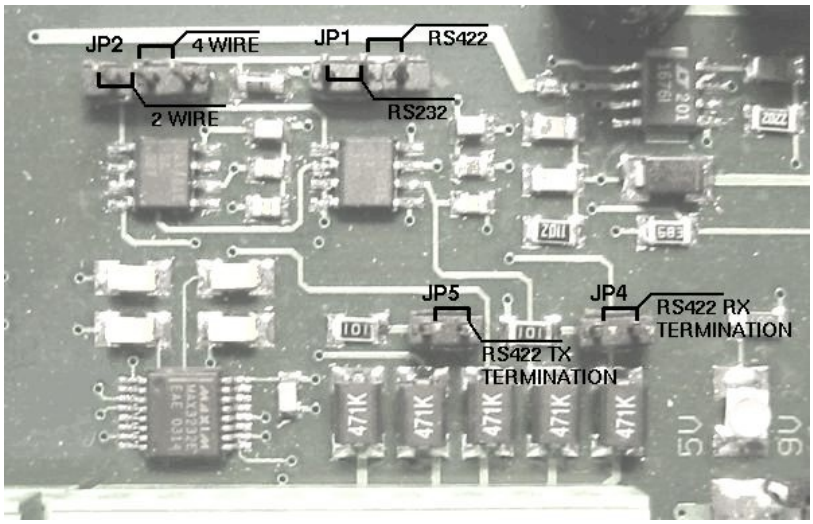
The ACU owns two serial interfaces. The first is reserved to poll a GPS receiver in order to get the antenna

geodetic location automatically. Any NMEA standard GPS receiver providing a RS232 interface may be connected here.

The second interface is used to control the ACU from remote where the TCP/IP remote control is not usable. This interface may be configured to work as a RS232 or RS422 interface by jumpers inside the ACU.

pin	*signal*	*description*	*type*
1	RS232 0 TX	RS232 for GPS receiver	OUT
2	RS232 0 RX		IN
3	GND		
4	RS232 1 TX	RS232 for remote control	OUT
5	RS232 1 RX		IN
6	GND		
7	RS422 TX+	RS422 for remote control	OUT+
8	RS422 TX-		OUT-
9	RS422 RX+		IN+
10	RS422 RX-		IN-

The ACU is factory preset to use the RS422 interface in 4-wire configuration. To change the interface configuration, set the jumpers on the ACU main board above CON8 according to the illustration below



- JP1 selects between the RS232 and the RS422 interface driver. Put the jumper to position 1-2 (left) to select the RS232 interface.
- JP2 switches between the RS422 4-wire mode and RS485 2-wire mode. To select RS485 2-wire mode put the jumper to position 1-2 (left). Use the TX data lines (CON8 Pins 7, 8) in this mode.
- JP4 and JP5 activate 100 Ohms termination resistors between the RS422 data lines. The lines are terminated if the jumper is set.

CON9 Power Supply

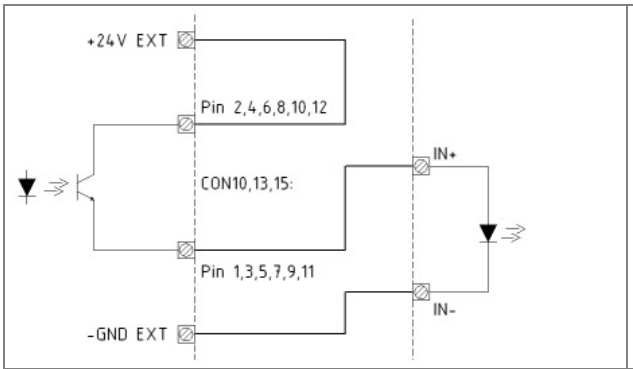
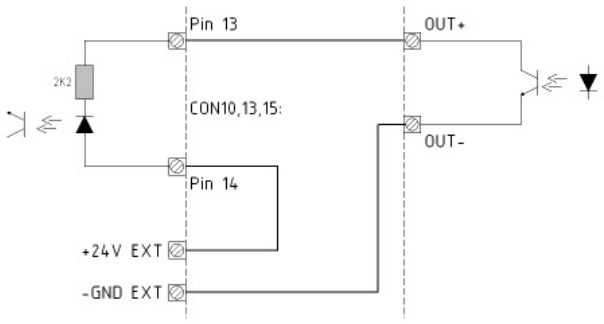
At CON9 the power supply for the ACU itself (pins 1, 2) and for the external switches must be connected. Also see chapter 4.2.3 Power Supply Cabling for the concept of separate intern / extern power supplies the ACU uses.

pin	*signal*	*description*	*type*
1	+24V ACU	power supply for the ACU and the	
2	GND ACU	positional encoders	
3	+24V EXT	power supply for motor drivers and	

4	GND EXT	external switches	

CON10 Azimuth Motor Driver

All signals for motor control are provided as free floating opto coupler inputs / outputs. This gives a maximum of flexibility to adapt the cabling to the motor driver units. They probably will combine one end of the control inputs to a common potential. The ACU is capable to control motor drivers with different polarity concepts.

	Example for wiring the motor drive signals
	Example for wiring the motor status signals

The ACU knows two different configuration modes to control a motor driver. They are called 'DIR-START' and 'DUAL-START'. In 'DIR-START' mode, the 'FWD' signal switches the motor on/off, the 'REV' signal controls the motor direction. This is the configuration many frequency inverters use. In 'DUAL-START' mode, the 'FWD' signal switches the motor on in forward direction, 'REV' activates the motor in reverse direction. This configuration mode is convenient to control a motor with relays.

The movement direction for the azimuth drive must be cabled as follows: FWD moves the antenna to the west (to the right on the northern hemisphere). The evaluation routines in the software which compute the antenna pointing for a given satellite location require the movement direction in this way.

The AZ RESERV reflects the "motor stopped" state of the axis. ON signals the OK state, the signal turns off in case of a motor fault, timeout, or if the emergency stop signal is received. Depending on the reason of the motor stop a motor reset command may be neccessary to release the axis from this state.

pin	*signal*	*DUAL-START*	*DIR-START*	*type*
1	AZ FWD E	ON = motor on / right	ON = motor on	OUT-
2	AZ FWD C		OFF = motor off	OUT+
3	AZ REV E	ON = motor on / left	ON = direction left	OUT-
4	AZ REV C		OFF = direction right	OUT+
5	AZ SPD1 E	ON = slow	ON = slow	OUT-
6	AZ SPD1 C			OUT+
7	AZ SPD2 E	ON = fast	ON = fast	OUT-
8	AZ SPD2 C			OUT+
9	AZ RES E	reset driver	reset driver	OUT-

10	AZ RES C			OUT+
11	AZ RESERV E	axis stopped	axis stopped	OUT-
12	AZ RESERV C			OUT+
13	AZ FAULT K	driver fault	driver fault	IN-
14	AZ FAULT A			IN+

CON11 24V-EXT Distribution

CON11 provides four clamps to the 24V-EXT rail. It has been included to simplify the external cabling.

pin	*signal*	*description*	*type*
1	+24V EXT		
2	+24V EXT		
3	+24V EXT		
4	+24V EXT		

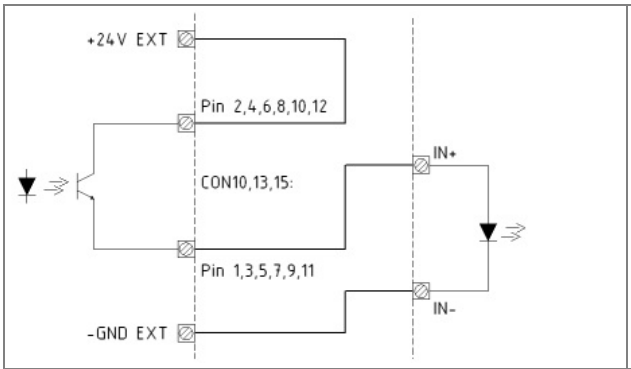
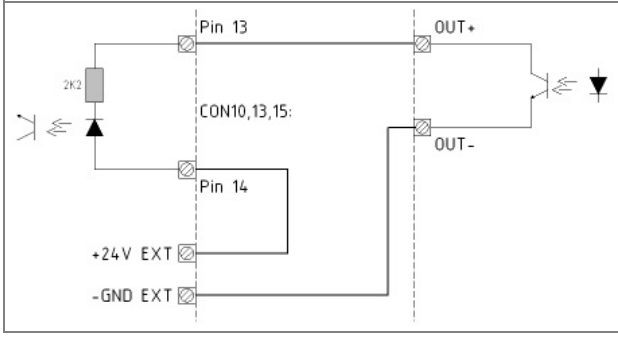
CON12 GND-EXT Distribution

CON12 provides four clamps to the GND-EXT rail. It has been included to simplify the external cabling.

pin	*signal*	*description*	*type*
1	GND EXT		
2	GND EXT		
3	GND EXT		
4	GND EXT		

CON13 Elevation Motor Driver

All signals for motor control are provided as free floating opto coupler inputs / outputs. This gives a maximum of flexibility to adapt the cabling to the motor driver units. They probably will combine one end of the control inputs to a common potential. The ACU is capable to control motor drivers with different polarity concepts.

	Example for wiring the motor drive signals
	Example for wiring the motor status signals

The ACU knows two different configuration modes to control a motor driver. They are called 'DIR-START' and 'DUAL-START'. In 'DIR-START' mode, the 'FWD' signal switches the motor on/off, the 'REV' signal controls the motor direction. This is the configuration many frequency inverters use. In 'DUAL-START' mode, the 'FWD' signal switches the motor on in forward direction, 'REV' activates the motor in reverse direction. This configuration mode is convenient to control a motor with relays.

The movement direction for the azimuth drive must be cabled as follows: FWD moves the antenna to the west to the right on the northern hemisphere. The evaluation routines in the software which compute the antenna pointing for a given satellite location require the movement direction in this way.

The EL RESERV reflects the "motor stopped" state of the axis. ON signals the OK state, the signal turns off in case of a motor fault, timeout, or if the emergency stop signal is received. Depending on the reason of the motor stop a motor reset command may be neccessary to release the axis from this state.

pin	*signal*	*DUAL-START*	*DIR-START*	*type*
1	EL FWD E	ON = motor on / right	ON = motor on	OUT-
2	EL FWD C		OFF = motor off	OUT+
3	EL REV E	ON = motor on / left	ON = direction left	OUT-
4	EL REV C		OFF = direction right	OUT+
5	EL SPD1 E	ON = slow	ON = slow	OUT-
6	EL SPD1 C			OUT+
7	EL SPD2 E	ON = fast	ON = fast	OUT-
8	EL SPD2 C			OUT+
9	EL RES E	reset driver	reset driver	OUT-
10	EL RES C			OUT+
11	EL RESERV E	axis stopped	axis stopped	OUT-
12	EL RESERV C			OUT+
13	EL FAULT K	driver fault	driver fault	IN-
14	EL FAULT A			IN+

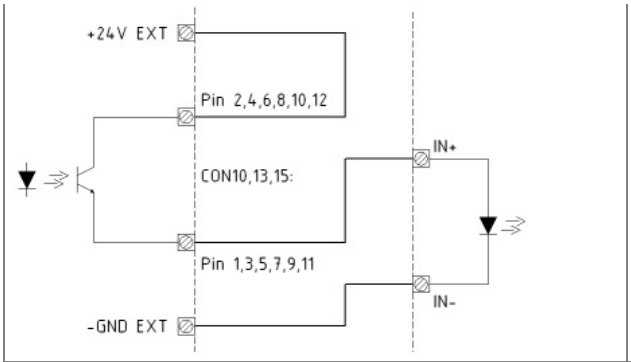
CON14 GND-EXT Distribution

CON12 provides eight clamps to the GND-EXT rail. It has been included to simplify the external cabling.

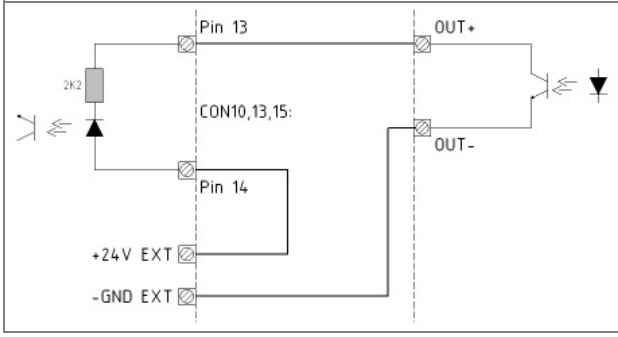
pin	*signal*	*description*	*type*
1	GND EXT		
2	GND EXT		
3	GND EXT		
4	GND EXT		
5	GND EXT		
6	GND EXT		
7	GND EXT		
8	GND EXT		

CON15 Polarization Motor Driver

All signals for motor control are provided as free floating opto coupler inputs / outputs. This gives a maximum of flexibility to adapt the cabling to the motor driver units. They probably will combine one end of the control inputs to a common potential. The ACU is capable to control motor drivers with different polarity concepts.



Example for wiring the motor drive signals



Example for wiring the motor status signals

The ACU knows two different configuration modes to control a motor driver. They are called 'DIR-START' and 'DUAL-START'. In 'DIR-START' mode, the 'FWD' signal switches the motor on/off, the 'REV' signal controls the motor direction. This is the configuration many frequency inverters use. In 'DUAL-START' mode, the 'FWD' signal switches the motor on in forward direction, 'REV' activates the motor in reverse direction. This configuration mode is convenient to control a motor with relays.

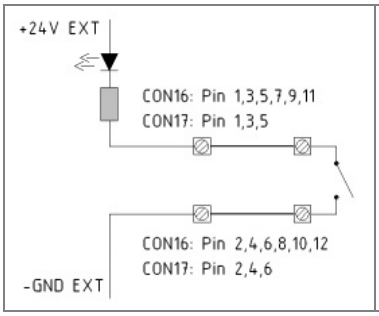
The movement direction for the polarization drive must be cabled as follows: FWD moves the feed clockwise when looking 'through the antenna' to the satellite. This is valid for the northern hemisphere, when operated on the southern hemisphere, the motor must be cabled for the opposite direction. The evaluation routines in the software which compute the antenna pointing for a given satellite location require the movement direction in this way.

The PL RESERV reflects the "motor stopped" state of the axis. ON signals the OK state, the signal turns off in case of a motor fault, timeout, or if the emergency stop signal is received. Depending on the reason of the motor stop a motor reset command may be necessary to release the axis from this state.

pin	*signal*	*DUAL-START*	*DIR-START*	*type*
1	PL FWD E	ON = motor on / right	ON = motor on	OUT-
2	PL FWD C		OFF = motor off	OUT+
3	PL REV E	ON = motor on / left	ON = direction left	OUT-
4	PL REV C		OFF = direction right	OUT+
5	PL SPD1 E	ON = slow	ON = slow	OUT-
6	PL SPD1 C			OUT+
7	PL SPD2 E	ON = fast	ON = fast	OUT-
8	PL SPD2 C			OUT+
9	PL RES E	reset driver	reset driver	OUT-
10	PL RES C			OUT+
11	PL RESERV E	axis stopped	axis stopped	OUT-
12	PL RESERV C			OUT+
13	PL FAULT K	driver fault	driver fault	IN-
14	PL FAULT A			IN+

CON16 Limit Switches

The limit switch inputs internally are connected to the external 24V / GND rails. The switches are connected directly to the input pairs without any external ground or supply cabling. The ACU treats a closed contact as OK, contacts have to be opened to indicate the 'limit reached' condition.



Example for wiring the limit switches

Please note, that the left/right azimuth and polarization limit switches have to be swapped when the antenna is operated at the southern hemisphere.

pin	*signal*	*description*	*type*
1	AZ High	azimuth right limit (view from behind antenna)	IN
2	GND EXT		IN
3	AZ Low	azimuth left limit (view from behind antenna)	IN
4	GND EXT		IN
5	El High	upper limit Elevation	IN
6	GND EXT		IN
7	El Low	lower limit Elevation	IN
8	GND EXT		IN
9	Pol High	polarization right limit (view from behind antenna)	IN
10	GND EXT		IN
11	Pol Low	polarization left limit (view from behind antenna)	IN
12	GND EXT		IN

CON17 Alarm Circuits

The alarm/stop switch inputs internally are connected to the external 24V / GND rails. The switches are connected directly to the input pairs without any external ground or supply cabling. The ACU treats a closed contact as OK, contacts have to be opened to activate the function noted in the table below.

The fault output are mechanical relays which connect '_C' (common) circuit to the '_NC' (normally closed) circuit while the ACU is powered and OK. In case of a fault or a lack of power supply the relays connect the '_NO' circuit to the '_C' circuit.

pin	*signal*	*description*	*type*
1	EMER_STOP	emergency stop (OK if closed)	IN
2	GND_EXT		IN
3	ANT_HUB_FAULT	alarm: hub fault (OK if closed)	IN
4	GND_EXT		IN
5	SW_CAB_OPEN	alarm: cabinet open (OK if closed)	IN
6	GND_EXT		IN
7	ACU_FLT_NC	acu alarm (connected to 9 if OK)	RELAY
8	ACU_FLT_NO	(connected to 9 if there is a FAULT)	RELAY
9	ACU_FLT_C		RELAY

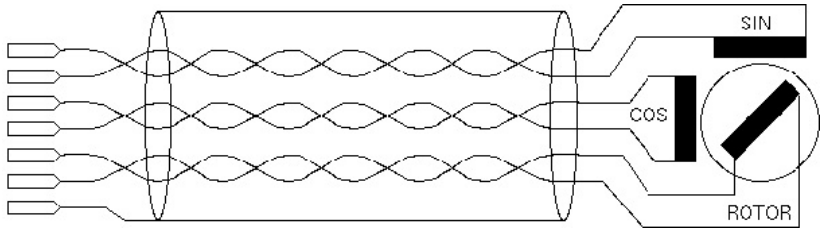
10	TRK_FLT_NC	tracking alarm (connected to 12 if OK)	RELAY
11	TRK_FLT_NO	(connected to 12 if there is a FAULT)	RELAY
12	TRK_FLT_C		RELAY

CON18, CON19, CON20 Resolver Interface

Below the pinout of a resolver type interface board is shown. The ACU is available with resolver, SSI or analog position sensor interfaces. You have to select type of interface when you order the ACU.

pin	*signal*	*description*	*type*
1	GND		
2	SIN	resolver SIN	IN
3	GND	resolver SIN	IN
4	COS	resolver COS	IN
5	GND	resolver COS	IN
6	REF	drive signal to resolver	OUT
7	GND	drive signal to resolver	OUT
8	GND		

The ACU resolver interface is designed for resolvers with an impedance of 100 Ohms or more and transfer factor 0.5. The interface applies 4Veff / 2000Hz to the resolver drive coil. It expects 2Veff at the sine / cosine inputs at the maximum positions.



When connecting a resolver to the ACU, please consider the following:

- Use a shielded, twisted pair cable.
- Connect the cable shield **either** to pin 1/8 at the ACU **or** to the ground at the resolver housing. Never connect the shield at both ends, this will introduce a ground loop and cause a significant degradation of the resolver's accuracy.

CON18, CON19, CON20 SSI Positional Encoder Interface

Below the pinout of a SSI type positional encoder interface board is shown. The ACU is available with resolver, SSI or analog position sensor interfaces. You have to select type of interface when you order the ACU.

The SSI positional encoder may be powered from the ACU internal power supply. +5V and +24V clamps are provided at the connector. To avoid ground loops, the cable shield should be connected **either** to pin 1 at the ACU **or** to the ground at the encoder housing, never at both ends.

pin	*signal*	*description*	*type*
1	GND		
2	SSI-Data+	SSI data	IN
3	SSI-Data-	SSI data	IN
4	SSI CLK+	SSI clock	OUT
5	SSI CLK-	SSI clock	OUT
6			

7	+5V	encoder power supply	
8	+24V	encoder power supply	

CON18, CON19, CON20 Analog Angle Sensor Interface

Below the pinout of an analog type positional sensor interface board is shown. The ACU is available with resolver, SSI or analog position sensor interfaces. You have to select type of interface when you order the ACU.

pin	*signal*	*description*	*type*
1	AGND	analog ground	OUT
2	INPUT	A/D converter input	IN
3	REF	reference voltage	OUT
4	AGND	analog ground	OUT
5	+15V (opt)	optional DC out	OUT
6	-15V (opt)	optional DC out	OUT
7	+9V (opt)	optional DC out	OUT
8	GND	digital ground	OUT

4.2.3 Power Supply Cabling

The ACU uses opto coupler interfaces to the motor drivers, limit switches etc. This permits to use a complete separate power supply with a separate ground for these circuits.

To simplify the cabling of these circuits, the ACU distributes the external 24V and GND lines through a separate set of clamps.

4.3 Start-up

This chapter describes how to install and start-up the ***sat-nms*** ACU-ODM. It is a step-by-step description without detailed description. If you need more detailed description for e.g. some parameter settings, please refer to chapter 5 Operation, all of the parameters are described here.

Before you start, please first read the Safety Instructions chapter. It contains some important recommendations to prevent damage from the ACU.

Then, we strongly recommend to do a first setup of the ACU on a lab desk before installing it at it's final location. This is mainly for the following reason:

To setup the ACU's IP parameters, the PC used for configuring and the ACU must either be connected to the same Ethernet hub or must be connected directly with a crossover cable. The initialization program does not work through routers or intelligent network switches.

Hence, the typical sequence of tasks when putting an ***sat-nms*** ACU outdoor module into operation is as follows:

1. Read the chapter Safety Instructions.
2. Set the ACU's IP address.
3. Mechanically mount the ACU.
4. Connect the ACU to the antenna (position encoders, limit switches and motor drivers). Finally connect the UPS power supply and the Ethernet network.
5. Start up the system and set the parameters as described below.
6. As last step connect the power supply of the motors and start them up as described below.

4.3.1 Setting the IP Address

Before you can operate the ***sat-nms*** ACU-ODM, you need to set the ACU's IP address. There is a special configuration program on the documentation CD shipping with the ACU for this purpose. We recommend to configure the ACU's TCP/IP settings before you install the ***sat-nms*** ACU-ODM at it's final place. To

configure the ACU, the following equipment is required:

- The ***sat-nms*** ACU-ODM itself.
- a 24V DC power supply.
- A Computer running a Microsoft Windows operating system equipped with CD-ROM drive and Ethernet network card.
- A CAT5 crossover network cable or an Ethernet hub and standard network cables to connect the ACU and the computer.
- The CD-ROM shipping with the ***sat-nms*** ACU-ODM.

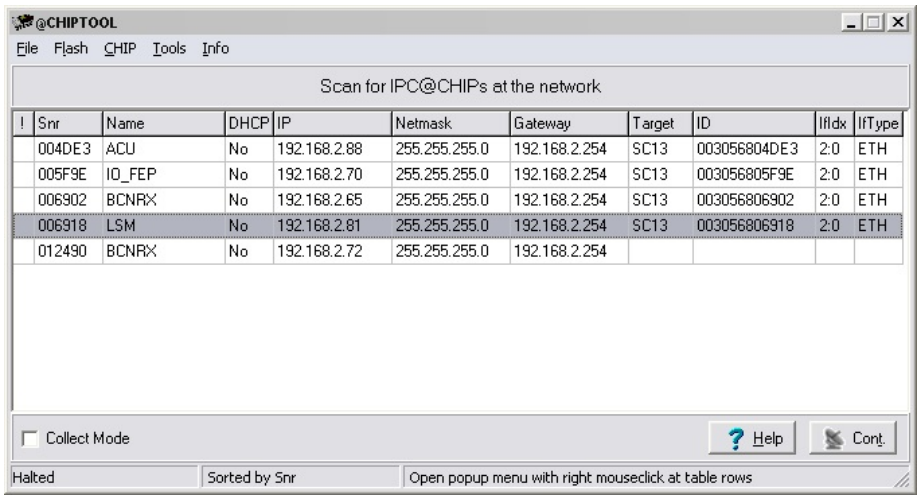
Setting the ACU's IP parameters now is easily done within a few minutes.

1. First install a network cable between the ACU and your computer. If you have a crossover cable available, this is very easy: simply put the cable into the network connectors of computer and ACU. Without a crossover cable, you need to connect both, the computer and the ACU to the same network hub using two standard network cables. It is essential, that the computer and the ACU are connected to the same network segment, the configuration program is not able to find the ACU through routers or network switches.

2. Now power on your computer and connect the ACU to the 24V DC power supply.

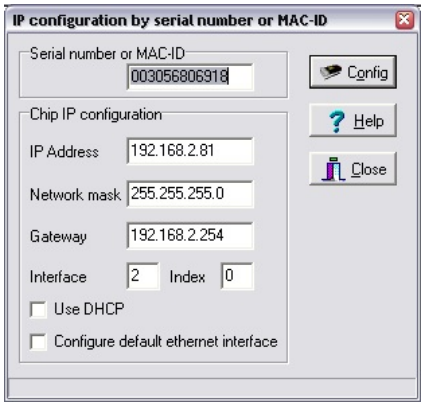
3. Insert the CD-ROM into the computer's drive and inspect it's contents through the 'My Computer' icon on your desktop. Double-click to the 'ChipTool.exe' program in the 'ChipTool' directory.

4. When the ChipTool program is running, the program shows a list containing at least one entry describing the actual network parameters of the ***sat-nms*** ACU-ODM.


@CHIPTOOL
File Flash CHIP Tools Info
Scan for IPC@CHIPs at the network
! Snr Name DHCP IP Netmask Gateway Target ID IfIdx IfType
004DE3 ACU No 192.168.2.88 255.255.255.0 192.168.2.254 SC13 003056804DE3 2:0 ETH
005F9E IO_FEP No 192.168.2.70 255.255.255.0 192.168.2.254 SC13 003056805F9E 2:0 ETH
006902 BCNRX No 192.168.2.65 255.255.255.0 192.168.2.254 SC13 003056806902 2:0 ETH
006918 LSM No 192.168.2.81 255.255.255.0 192.168.2.254 SC13 003056806918 2:0 ETH
012490 BCNRX No 192.168.2.72 255.255.255.0 192.168.2.254
Collect Mode
Help
Cont.
Halted
Sorted by Snr
Open popup menu with right mouseclick at table rows

5. The serial number of the core module shown in the first column of the list. If the list stays empty, the ACU is not connected properly. If there are more entries in the list, the configuration program has found other devices in this network segment which use the same technology.

6. Now open with a right-click the sub-menu `IP configuration` to open the IP configuration window of the program. In this form the ACU's MAC address is shown on top, below you find the fields to configure the new IP address and network mask. If the ACU later shall be operated through a router, enter the address of the router on the gateway field, otherwise leave this field blank. Be sure, that the 'DHCP' mark is unchecked, the other values have to be set as shown on the picture. Finally click to the 'Yes' button to set the new parameters at the ACU.



Now the IP configuration of the ACU is completed. You may finally want to test if the ACU is reachable now. Start your web browser and type the ACU's IP address into the URL field of the browser. The ACU should reply with it's main page, provided that the ACU and your computer are configured for the same subnet.

4.3.2 Limit switches

Connect the limit switches to the ***sat-nms*** ACU-ODM as described in chapter 4.2.2 Pin description.

1. Apply 24V DC to the ACU-ODM. Take care, that the motor drivers are not powered up yet. The ***sat-nms*** ACU-ODM should be reachable via Ethernet now.
2. Check the function and correlation of all limit-switches manually. On the ***sat-nms*** ACU-ODM main-webpage a limit fault is shown as soon it occurs. On the test-page every single limit switch is displayed. For more detailed informations see chapter 5 Operation

4.3.3 Angle detectors

Connect the angle detectors to the ***sat-nms*** ACU-ODM as described in chapter 4.2.2 Pin description.

1. Configure the desired type of detector on the setup-page.
2. Set the soft-limits to the expected values (at first it is ok if you do this approximately, later on you need to type in here the exact values).
3. Check the rotational direction of the resolvers. If possible, do this by turning the resolver axis directly, otherwise you have to move the antenna by hand. Maybe you have to invert the rotational direction on the setup page.
4. Set the offset of the angle detectors to the desired values by using the `calc` function

If you need more detailed information, please refer to chapter 5.6 Setup.

4.3.4 Motors

Before you connect the motors to the ***sat-nms*** ACU-ODM, take care that the motor drivers are not powered up yet.

1. Connect the motor drivers to the ***sat-nms*** ACU-ODM as described in chapter 4.2.2.
2. Press the `STOP` button on the ***sat-nms*** ACU-ODMs website. By this you can be sure that no motor movement will occur by switching on the motor drivers.
3. Turn on power supply for the motor drivers, they have to run now.
4. If you use frequency inverters as motor drivers, set now the motor parameters to the frequency inverters as written in their documentation.
5. Check the motor rotating directions, if necessary change it by interchanging 2 phase-wires of the motor cable (3phase motor) or interchange + and - cable (DC motor).
6. Drive the antenna in every direction (AZ, EL and if available POL) until the limit switches stop the motor movement to ensure that the limit switches work well.
   ATTENTION! While doing this test it is absolutely necessary to be very mindful to check, if nothing collides!
7. Set the soft-limits to the desired values (e.g. 1° before the hardware limit switch is activated)

4.3.5 Pointing/ Tracking

Now, the setup of all interfaces to the antenna is done. By this everything is prepared to configure the ACU to the desired operation mode, to save targets and finally to set the ***sat-nms*** ACU-ODM into service.

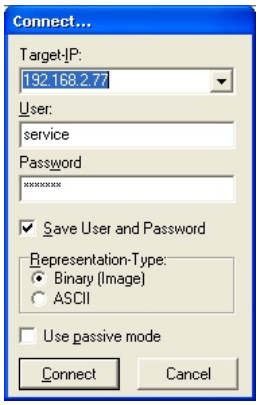
In chapter 5 Operation you find a detailed description of the pointing and tracking parameters.

To use the function pointing by stating an orbit position you have to configure the 'Location' parameters on the setup page to the geodetic location of your antenna. Take care to type in position with enough accuracy (0.001°). For further informations, please refer to chapter 5.6 Setup for location parameters and 5.3 Target Memory for using this pointing function.

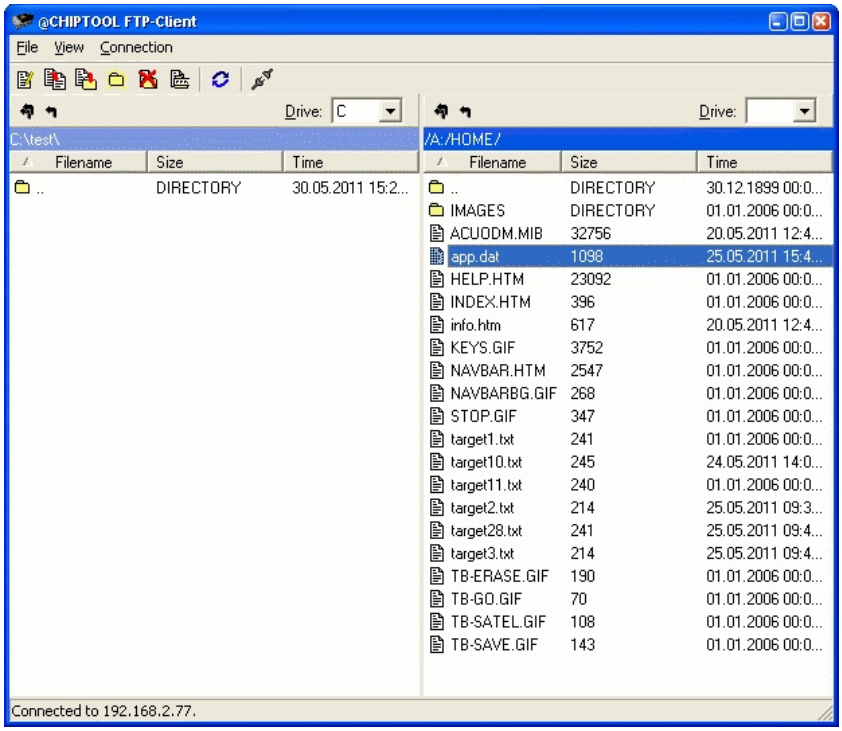
4.3.6 Backup of ACU settings

The last step that is recommended to be done is the backup of ACU settings. By this way an easy replacement of the ACU-ODM could be performed.
The following step-by step description shows how to do this.

1. Open the chiptool
2. Right click to the desired unit. A drop-down list will open, choose `FTP`
3. A small window like shown on the following picture will be opened. Please double-check the displayed IP, you might adjust it in the drop-down list here.



4. Login with username `service` and password `service`
5. Now you see on the right side the file system of the ACU like shown on the following picture. On the left side you see the computers file system.



6. Browse on the left side to the desired location to which you like to save the backup
7. Right-click the `app.dat` file and choose `copy` in the drop down list. The file will immediately be copied to the location shown on the left side. If you have saved targets, you might backup them in the same way. They are named `targetXX.txt`. XX represents the number of the target.
8. To copy a backup file to the ACU, browse on the left side if the window to the desired `app.dat` file and copy this file to the ACU in the same way (right click->copy)
9. After copying an `app.dat` file to the ACU, you have to reboot the unit (power off). By next starting up, the new `app.dat` file will be used.

5 Operation

The ***sat-nms*** ACU outdoor module is designed to be controlled over a network link using a standard web browser. This means in practice, that the user interface to the ACU appears in your browser window after you type in the ACU's IP address in the address field of the browser program.

Operating the ACU is mostly self-explanatory.

5.1 The Web-based User Interface

After having connected the ACU to a power supply and set the ACU's IP address, you can access the ACU's user interface. To do this, start your favorite web browser program (Internet Explorer, Netscape Navigator, Opera or what else program you prefer). At the address field, where you normally enter the URL of a web page you want to see, type in the IP address of the ***sat-nms*** ACU you want to control.

The ACU shows a web page consisting of a navigation bar at the left side of the browser window and the actual antenna pointing in the main part of the window. The readings automatically refresh once a second. The refresh-rate may be adjusted on the setup-page from software version 2.1.007 or higher.

The navigation bar at the left contains a couple buttons which build the ACU's main menu:

Pointing: This button switches back to the main page you already see when you connect to the ACU. This page displays the actual antenna pointing together with some status information. You also use this page to move the antenna to a certain pointing given as azimuth / elevation values.

Target: By clicking to this button you switch to the 'Target' page where you can store and recall the antenna pointing for up to eight satellites.

Tracking: ***sat-nms*** ACUs with the tracking option installed offer the tracking mode and tracking fine tune parameters on this page.

Test: By clicking to this button you switch to the 'Test' page. The 'Test' page shows the low level I/O signals of the ACU. It helps you to install the ACU or to identify a malfunction of peripheral components.

Setup: This button switches to the 'Setup' page which lets you inspect or change less common parameters which usually are set only once to adapt the ACU to it's working environment.

Info: After a mouse click to this button, the ACU outdoor module shows a table with information like the serial number of the device or the revision ID and compilation date of the software.

Help: Clicking to this button shows the on-line version of this user manual

Step Move: Clicking to the buttons in this area moves the antenna a small step to the indicated direction. For azimuth and elevation 'small step' and 'large step' buttons are provided. A 'small step' is the angle defined with the 'XX step delta' parameters at the Setup page, a 'large step' is ten times this value. With the polarization axis, steps always are 1°.

STOP: Clicking to the STOP button immediately stops all motors. The ACU indicates a fault. A click to the RESET button releases this fault.

RESET: The RESET button lets the ACU acknowledge any motor diver faults by activating the reset-circuit to the motor drivers for 800 msec. All faults internally latched by the ACU are cleared and the target pointing values are set to the values actually read from the position sensors.

5.2 Antenna Pointing

The 'Pointing' page is the main page of the ACU user interface which shows the actual antenna pointing and some status information. The 'Pointing' page automatically refreshes once a second. The refresh-rate may be adjusted on the setup-page from software version 2.1.007 or higher. The table below describes the information shown by this page:

Parameter Name	*Description*
Azimuth Elevation Polarization	The bold printed figures show the actual antenna pointing angles as read from the position sensors. If the polarization axis is not controlled by the ACU, '-.---°' is displayed in the polarization field.
Xx. target value	Below the measured angles the ACU displays the target values of the antenna pointing. The target values are the angles which have been commanded to the ACU. You may click to a target angle in order to change the pointing manually. The ACU display a dialog page where you can enter the new pointing angle. If you click to the 'SUBMIT' button in this dialog page, the antenna immediately moves to the new position. To go back to the main page without changing the pointing, click to the 'Back' button of your Web browser.
Axis state flags	Below the target values, for each axis there is a field reserved which contains some state information for this axis. While the motor is running, 'MOVING' is displayed at this place. If the motor has been stopped due to a fault or an emergency stop request, a red label 'STOPPED' is displayed. Finally, if the ACU recognizes the activation of a limit switch, the orange colored label 'LIMIT' is displayed in this field.
Target name	The name of the satellite the antenna is pointing to. Click to the name to get a dialog page where you can change the name. The name is stored together with a satellite's pointing at the target memory page. If you change the target pointing values, the target name is set to 'unknown' by the ACU. Hence you first should adjust the antenna pointing, then enter the satellite's name.
Tracking mode	***sat-nms*** ACUs with the tracking option installed display the actual tracking mode / state in this field. ACUs without tracking show 'OFF' all the time. In STEP and ADAPTIVE tracking modes this field shows what the tracking actually is doing and some information about the tracking data in memory: fill tells how many hours of step track data for calculating a model the ACU actually has in memory. This data may be used in ADAPTIVE mode to predict the satellite movement in case of a beacon failure. The smoothing which may be applied to the step track also relies on this data. age means the age of the most recent successful tracking step. In other words this describes how many hours ago the beacon was lost in case of a beacon failure.
Beacon level	This field shows the beacon level as read from the beacon receiver. Depending on the source defined at the Setup page, this either is the beacon level reported by a ***sat-nms*** LBRX beacon receiver via TCP/IP of the level derived from the ACU's analog input.
Temperature	The actual temperature inside the ACU enclosure. This value is for information only.
ACU Faults	If there are any faults with the ACU, they are displayed in this field. If there is more than one fault at a time, the ACU concatenated the fault descriptions. More detailed information about faults are available in chapter Faults and Tracking. If one axis stops operation due to a fault, the step tracking also stopps operation. Possible faults are: EMERGENCY-STOP: Someone opened the emergency stop circuit. The ACU stopped all motors and stays in this state until the 'RESET' button at the navigation bar is clicked. HUB-FAULT: The ACU detected a 'hub fault' condition. CABINET-OPEN: The ACU detected a 'cabinet open' condition. BCRX-TIMEOUT: If the ACU reads the beacon level via TCP/IP from a ***sat-nms*** LBRX and the latter does not respond, a BCRX-TIMEOUT fault is reported
Tracking Faults	If the ACU has the tracking option installed, any faults of the tracking module are shown in this field. With tracking option, this field is always empty.
AZ/EL Tracking	If the ACU has the tracking option installed and ADAPTIVE tracking is selected, these give some information about the model of antenna/satellite movement the ACU has

State	calculated from the step track data:	
	M (model)	The complexity of the model the ACU uses (small/medium/large). With a small amount of tracking data available, the ACU uses a smaller, less complex model than with a completely filled tracking memory.
	A (amplitude)	The amplitude of the antenna movement in this axis, expressed as a percentage of the full 3dB beamwidth.
	J (jitter)	The jitter of the antenna movement in this axis, expressed as a percentage of the full 3dB beamwidth.
	B (beamwidth)	The 3dB beamwidth as calculated by the ACU from the antenna diameter in this axis and the beacon receive frequency. This is the full beamwidth, the angle between both 3dB points in the antenna pattern.
	S (step size)	The absolute step size used by the step track in this axis.
Time	The actual time of the ACU's internal clock.	
GPS State	The actual state of an external GPS receiver connected to the ACU (if applicable).	

Antenna Pointing Page Example:

Azimuth	Elevation	Polarization
219.089°	27.471°	-70.049°
Target value 219.080 °	Target value 27.461 °	Target value -70.082 °

Target name	SES4 22°W RX 11451M003
Tracking mode	ADAPTIVE (SLEEPING) (sleep=317s fill=111.1h age=0.0h)
Beacon level	-82.54 dBm (var 0.00 dB)
Temperature	36.8 °C
ACU Faults	
Tracking Faults	
AZ Tracking State	M=SMALL A=11% J=1% B=0.496° S=0.056°
EL Tracking State	M=SMALL A=15% J=2% B=0.496° S=0.050°
Time	2012-11-27 12:42:37
GPS State	DISABLED

5.3 Target Memory

The page 'Targets' gives access to the ACU's target memory. The ACU is capable to remember the pointing (and tracking parameters, if the ACU has the tracking module installed) of up to 99 satellites. Managing these memories is done with the 'Targets' page.

The page displays a table with all pointings actually stored. By clicking the icons in the table, settings may be stored, recalled or deleted:

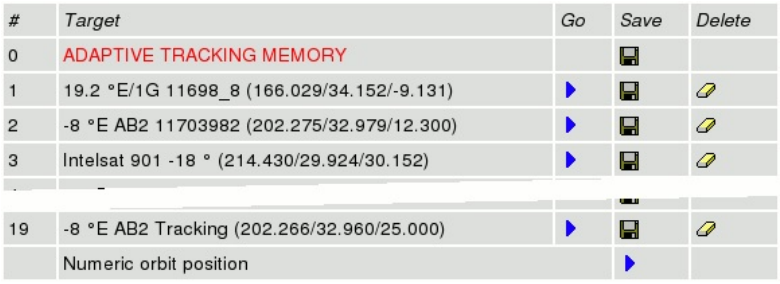
Go	If a memory location has stored a pointing, the table shows a blue arrow in the 'Go' column of the table. Clicking to this arrow recalls the settings stored for that target and moves the antenna to the stored pointing. The ACU displays a confirmation dialog before it actually recalls the target memory. Only if you click to 'Submit' in this dialog, the antenna moves to the stored location.
Save	For each memory location the table shows a floppy disk icon in the 'Save' column. Clicking to this icon saves the actual pointing (and tracking parameters if applicable) to the selected memory location. Again, there is a confirmation dialog page before the data actually is saved.
Delete	Analogous to the 'Save' icon, the table shows an eraser icon in the 'Delete' column. The icons only are shown for the memory locations which are in use. Clicking to the eraser icon clears the selected memory location after a confirmation inquiry.
Numeric orbit	The table contains an additional row at the bottom labeled 'Numeric orbit position'. Clicking to the blue arrow icon in this row opens a dialog where you are requested to enter the orbit

position	position of a satellite you want the antenna to point to. After you pressed 'Submit' in this dialog, the ACU computes the antenna pointing for the orbit position you entered and **immediately** moves the antenna to the calculated position. To make this function work satisfactory, it is necessary to have the geodetic location of the antenna entered at the Setup page with a sufficient accuracy.

The first target location, labeled 'adaptive tracking memory', is reserved for special purposes: If you store to this target location, this saves the tracking parameters and the tracking memory as well. When this memory location is recalled later on, the parameters and the memory contents are restored. This may be useful to track another satellite for a couple of hours and then to return to the first satellite. If the tracking memory has been saved before the antenna has been moved to the second satellite, it may be restored after the antenna returned to the old position.

You should not use the first target location for general purposes in order to keep it available for the short time storage described above.

Targets Page Example:



5.4 Tracking Parameters

sat-nms ACUs with the tracking function installed give access to the tracking mode and the fine tune parameter which lets you adapt the tracking to the individual requirements of the antenna and the satellite you are tracking to. ACUs without tracking function show an empty page at this place.

Tracking mode	The tracking mode parameter selects the tracking method, the ACU actually uses. Possible selection are: **OFF** No tracking is performed. **STEP** Step track mode. In regular intervals, the antenna performs small search steps to optimize the pointing. Chapter '8.3.0 Step Track' gives more information about this mode. **ADAPTIVE** The adaptive tracking mode works the same way as step track, but it additionally is capable to predict the satellite's position when the beacon reception fails. It computes mathematical models of the satellites motion from the step track results recorded over a certain time. Details about this tracking mode are given in chapter '8.4.0 Adaptive Tracking'. **PROGRAM** The program tracking mode is different from the modes above. The ACU moves the antenna along a path which is described in a data file. No beacon reception is required for this. You have to create such a data file and copy it with FTP to the ACU before you can use this mode. SatService GmbH provides a PC software which lets you easily create data files for program track from commonly used ephemeris data sets for geostationary satellites. Chapter '8.5.0 Program Tracking' describes this tracking mode more detailed.
CLEAR MEMORY	Clicking to this mark clear the tracking memory. You should do this when you start to track a new satellite. Clearing the tracking memory about half an hour after tracking started significantly improves the quality of the first

	adaptive tracking model which will be evaluated after 6 hours of tracking. This is because the model does not get disturbed by the first search steps the antenna does until the optimal pointing to the satellite is found.
Tracking step size	The tracking step size is a very important parameter for the performance of the tracking. It defines the size of every depointing step, the ACU makes in order to find out where the optimal antenna pointing is. Setting too high values will cause significant signal degradations during the step track cycle because the antenna moves a too large amount away from the satellite. Setting the value too small will let the beacon level jitter mask the level differences caused by the test steps, the antenna will not track the satellite properly. The step size is specified as a percentage of the antenna's half 3dB beamwidth. The ACU calculates the beamwidth from the antenna diameter and the beacon frequency. Expressing the step size in this relative way keeps the value in the same range, regardless of the type of antenna. The recommended value for this parameter is 15-20%. You may want to start with 20% and try to reduce down to 15% if the signal degradation during tracking becomes too high. The tracking step size is a common parameter for both axes. If both axes behave differently, you can tweak the antenna diameter settings in the setup. Specifying a larger diameter makes the ACU using a smaller step size for this axis. If the tracking step seems to be completely out of range, you should check if the beacon frequency is set properly. The frequency must be the true receive frequency at the antenna, entered in MHz, not an L-band frequency or other IF.
Tracking cycle time	The cycle time specifies how often the ACU shall perform a step track cycle. The value is to be entered in seconds. In fact, the parameter does not specify a cycle time but the sleep time between two tracking cycles. This means, the true cycle time is the time the ACU needs to perform one step track cycle plus the time entered here. 300 seconds (5 minutes) is a good starting value for this parameter. Inclined orbit satellites probably will require a shorter cycle time, very stable satellites can be perfectly tracked with one step track cycle every 15 minutes (900 seconds). The maximum cycle time accepted by the ACU is 1638 seconds.
Measurement delay	During a steptrack cycle, the ACU positions the antenna to a certain offset and then measures the level. Between the moment when the antenna reached commanded position and the beacon level measurement the ACU waits some time to let the beacon level settle. The optimal delay value depends on the beacon receiver's averaging / post detector filter setting and is a quite critical for the steptrack performance. If the delay is too short, the beacon voltage does not reach its final value, the steptrack does not properly recognize if the signal goes better or worse after a test step. If the delay is too long, the impact of fluctuation to the measures level grows and may cover the small level difference caused by the test step. With the ***sat-nms*** LBRX beacon receiver, best results are achieved if the receiver is set to 0.5 Hz post detector filter bandwidth and a measurement delay of 1500 msec.
Recovery delay	After the ACU has done the tracking steps for the elevation axis, it waits some time before it starts tracking the azimuth axis. This is to let the beacon level settle after the final position has been found. A typical value for this parameter is 4000 msec.
Level averaging	When measuring the beacon level, the ACU takes a number of samples and averages them. The standard value of 5 samples normally should not be changed. Larger values will slow down the ACU execution cycle.

Level threshold	If the beacon level falls below this threshold value, the ACU does not perform a step track cycle. If the level falls below the threshold during the steptrack cycle, the cycle gets aborted. If the ADAPTIVE tracking is enabled and there is enough data in the tracking memory, the ACU computes a mathematical model from the stored data and predicts the antenna pointing position from the extrapolation of the model. If the tracking mode is set to 'STEP', the ACU leaves the antenna where it is if the beacon level drops below the limit. Adjusting the threshold level that adaptive tracking is switched as expected must be done carefully and may require some iterations, specially if the beacon is received with a low C/N. A good starting value for the threshold is 10 dB below the nominal receive level or 2 dB above the noise floor the beacon receiver sees with a depointed antenna, whatever value is higher. To turn off the monitoring of the beacon level (this in fact inhibits the adaptive tracking), simply set the threshold the a very low value (e.g. -99 dBm)
Smoothing interval	This parameter controls the smoothing function. Setting it to zero disables smoothing. Smoothing lets the ACU point the antenna to positions evaluated from a simple model calculated from the step track peaks of the recent few hours. A detailed description of this function you find at chapter '8.3.3 Smoothing'
Peak jitter threshold	If the jitter value of at least one axis exceeds this threshold, the ACU raises an 'model fault'. If this happens three consecutive times, the ACU resets the models of both axes. Adaptive tracking will be possible not until 6 hours after this happens. During adaptive tracking, the ACU evaluates for each axis a figure called jitter. The jitter value describes standard deviation of the measured peak positions with respect to the positions calculated from the (currently selected) model. The figure is also expressed as a percentage of the antenna's beamwidth, low values indicate, that the model ideally describes the antenna's path. High values indicate that's something wrong. The step track results may be to noisy at low amplitudes or the model does not fit at all. This may be the case if a satellite gets repositioned in the orbit. A typical threshold value is 20%, this will detect very early that a model does not fit to describe the satellite's motion. If this value causes false alarms too often, you may want to raise the threshold to 50%. Setting it to 0 switches the threshold monitoring completely off.
AZ Maximum model type **EL Maximum model type**	These settings let you limit the adaptive model to a simpler one, the ACU would choose by itself. The maximum model type can be set individually for each axis. Normally you will set both axes to 'LARGE', which leaves the model selection fully to the ACU's internal selection algorithms. In cases where the ACU seems to be too 'optimistic' about the quality of the step track results, the maximum model on one or both axes may be limited to a more simple and more noise-resistant model. Specially inclined orbit satellites which are located close to the longitude of the antenna's geodetic location may require this limitation for the azimuth axis. With such a satellite, the elevation may move several degrees while the azimuth shows almost no motion.

Please refer to chapter 8.3 Steptrack, 8.4 Adaptive Tracking and 8.5 Program Tracking for more detailed informations about the tracking algorithms.

Tracking Parameters Page Example:

Tracking mode	OFF		CLEAR MEMORY	
Tracking step size	15 %		Tracking cycle time	180 sec
Measurement delay	1500 msec		Recovery delay	4000 msec
Level averaging	5 samples		Level threshold	-75.00 dBm
Smoothing interval	6 h		Peak jitter threshold	0 %
AZ Maximum model type	LARGE		EL Maximum model type	LARGE

5.5 Test Page

The page 'Test' displays the electrical / logical level of all inputs and outputs of the ACU. This helps you to install the ACU or to identify a malfunction of peripheral components. Below some information how to interpret the values in this page are given.

Electrical I/O Levels

The electrical state of an input or output is indicated by the HI / LO label displayed with the signal. HI means that current is flowing through the optocoupler for this input or output. LO means that no current flows. As some signals are defined to be 'true' when a switch is opened, the electrical level of the signal not necessarily describes the logical level of this signal, too.

Logical I/O Levels

The logical level of an input or output is described by it's color: Green means this signal is inactive, OK or 'false'. Read means the signal is active or 'true'.

Toggling output levels manually

The 'Test' page also lets you toggle the actual state of each output signal simply by clicking to the underlined HI/LO mark of the signal. If you do this, you should consider the following:

- The ACU sets the motor driver outputs eight times a second for each axis having the motor driver type set to 'DIR-START' or 'DUAL-START'. This immediately will overwrite any change you make. If you want to test if the motor driver outputs command the motor driver as expected, switch the motor driver type for this axis to 'NONE' at the Setup page before you set the outputs manually.
- The 'Test' page is re-read by the Web-browser about once a second. Some browsers seem to ignore mouse clicks occasionally due to the screen refresh.

Adaptive tracking coefficients:

In adaptive tracking mode the ACU displays the coefficients of the actual model in two lines at the bottom of the text page. The number of coefficients displayed depends on the size of the model:

SMALL: *a0,a1,a2* (1)
MEDIUM: *a0,a1,a2,a3,a4* (2)
LARGE: *a0,a1,a2,a3,a4,a5* (3)

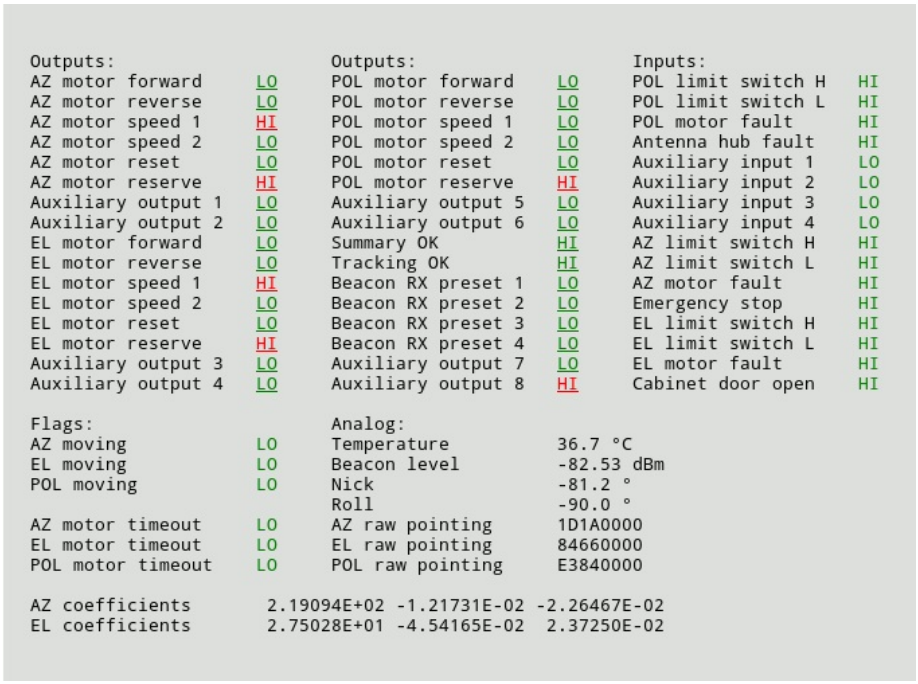
If the beacon signal drops below it's theshold, the antenna movement is calculated from these coefficients using the formulas shown below:

$$\alpha_{small} = a_0 + a_1\cos(\omega t) + a_2\sin(\omega t) \quad (1)$$

$$\alpha_{medium} = a_0 + a_1\cos(\omega t) + a_2\sin(\omega t) + a_3\cos(2\omega t) + a_4\sin(2\omega t) \quad (2)$$

$$\alpha_{large} = a_0 + a_1\cos(\omega t) + a_2\sin(\omega t) + a_3\cos(2\omega t) + a_4\sin(2\omega t) + a_5 t \quad (3)$$

Hardware Test Page Example:



Outputs:		Outputs:		Inputs:	
AZ motor forward	LO	POL motor forward	LO	POL limit switch H	HI
AZ motor reverse	LO	POL motor reverse	LO	POL limit switch L	HI
AZ motor speed 1	HI	POL motor speed 1	LO	POL motor fault	HI
AZ motor speed 2	LO	POL motor speed 2	LO	Antenna hub fault	HI
AZ motor reset	LO	POL motor reset	LO	Auxiliary input 1	LO
AZ motor reserve	HI	POL motor reserve	HI	Auxiliary input 2	LO
Auxiliary output 1	LO	Auxiliary output 5	LO	Auxiliary input 3	LO
Auxiliary output 2	LO	Auxiliary output 6	LO	Auxiliary input 4	LO
EL motor forward	LO	Summary OK	HI	AZ limit switch H	HI
EL motor reverse	LO	Tracking OK	HI	AZ limit switch L	HI
EL motor speed 1	HI	Beacon RX preset 1	LO	AZ motor fault	HI
EL motor speed 2	LO	Beacon RX preset 2	LO	Emergency stop	HI
EL motor reset	LO	Beacon RX preset 3	LO	EL limit switch H	HI
EL motor reserve	HI	Beacon RX preset 4	LO	EL limit switch L	HI
Auxiliary output 3	LO	Auxiliary output 7	LO	EL motor fault	HI
Auxiliary output 4	LO	Auxiliary output 8	HI	Cabinet door open	HI

Flags:		Analog:	
AZ moving	LO	Temperature	36.7 °C
EL moving	LO	Beacon level	-82.53 dBm
POL moving	LO	Nick	-81.2 °
		Roll	-90.0 °
AZ motor timeout	LO	AZ raw pointing	1D1A0000
EL motor timeout	LO	EL raw pointing	84660000
POL motor timeout	LO	POL raw pointing	E3840000

AZ coefficients	2.19094E+02	-1.21731E-02	-2.26467E-02
EL coefficients	2.75028E+01	-4.54165E-02	2.37250E-02

5.6 Setup

The page 'Setup' contains the ACU's installation parameters. The page displays a table with the parameters actually set. Each parameter value is a hyper-link to a separate page which lets you change this parameter. This parameter change page shows the actual parameter setting either in an entry field or in a drop down box. You may change the parameter to the desired value and then click to the 'Submit' button to pass the changed value to the ACU ODM. The ACU automatically returns to the setup page when the parameter has been changed. To cancel a parameter modification you already started, either use the 'Back' button of you web browser or click to the 'Setup' button on navigation bar. Both returns to the setup page without changing the parameter you edited.

The table below lists the settings provided by this page.

General

This section of the setup page contains some general setup parameters.

Parameter Name	*Description*
Axes control mode	The ACU knows two axes control modes. The PARALLEL mode treats the azimuth/elevation axes independently. If a new pointing is commanded, both motors are activated in parallel, the antenna moves to the new location in the shortest possible time. In SEQUENTIAL mode, the ACU does not move the elevation axis while the azimuth motor is running. The antenna movement is done sequentially: First azimuth, then elevation. You should prefer the PARALLEL mode unless special conditions require a sequential antenna movement. The performance of the ACU in terms of pointing speed and wind load compensation will be much better in PARALLEL mode.
Date / time	By changing this value you can set the internal clock of the ACU. The clock is set as soon you click to the 'Submit' button in the data entry dialog. The most precise method to set the time is to enter a time one or two minutes ahead and click to 'Submit' when this time is reached.
RS485 address	With this parameter you select the device address used control the ACU through a serial interface. See chapter 7.3 The RS232 remote control interface for more information about this. At ACU-RMU and ACU19 this parameter has to be set to 'NONE'. If you use a ***sat-nms*** Handheld this parameter has to be set to 'TERM'. The Handheld function is not implemented in ACU-RMU and ACU19 Version.

Watchdog pulse on AUX8	The AUX 8 output may be configured to act as a heartbeat output. If enabled, the output switches every 1000 ms between on/off. If using this signal for an external watchdog circuit, be aware that in adaptive tracking mode delays of some seconds are possible while the acu calculates the orbital model.
Display refresh	With this parameter you select the refresh-rate of the ACU's main window. This parameter is available from software version 2.1.007 or higher.
Note	The ACU's pointing page by default shows the title 'Antenna pointing'. By entering a different text here, you can make the ACU show a customized title.

Azimuth / Elevation / Polarization

The Azimuth / Elevation / Polarization sections contains the parameters which are specific to the individual axis. They are the same for each axis.

Parameter Name	*Description*
Antenna diameter	Set this parameter to the dish diameter. Units with the tracking function installed use this value to estimate some tracking parameters. With offset antennas, the diameter settings are different for the azimuth / elevation axes. This lets the ACU calculate suitable tracking step sizes individually for each axis.
Step delta	This parameter defines size of a step the antenna moves when you click to the arrow buttons on the ACU main page. If you are using the arrow buttons to fine-tune the antenna pointing manually, the best value is the pointing hysteresis described below. This lets you move the antenna the smallest possible step when you click to an arrow button. For special applications however it might be helpful to set the step delta to a much greater value.
Position sensor type	With this parameter you set the type of position sensor the ACU shall read for this axis. Principally, the ACU is capable to read SSI, RESOLVER and ANALOG type position sensors. The selected sensor type **must** match the type of interface board installed in your ACU. It is not possible to switch from SSI to RESOLVER or vice versa without changing the interface module. When selecting a SSI type position encoder, also the number of bits and the encoding scheme must be selected. For the position sensor type parameter these values are combined to one name. E.g. 'SSI-13G' means 13 bit, Graycode SSI sensor, 'SSI-24B' means 24 bit binary encoded SSI sensor. Beside the SSI-xxX, RESOLVER and ANALOG selections this parameter offers the choice 'NONE' which tells the ACU not to read a position encoder at all. With this selection you can tell the ACU if the polarization is not to be controlled by the ACU. If you are using multiturn SSI encoders you will have to scale the reading (See 'Calibration scale' below).
Pre scale offset	The pre-scale calibration offset is added to the raw position encoder reading *before* scaling is applied. The pre scale offset is defined as an 8-digit hexadecimal value in normalized position encoder ticks (00000000-FFFFFFFF equivalent to the full range of the encoder (0-360° with single turn encoders). The pre scale offset must be adjusted to avoid any 7FFFFFF to 8000000 overflow within the used range of the encoder. The value is added to the encoder reading, neglecting an overfly eventually occurring. Thus, the offset implements a 360° turnaround automatically. The pre scale offset may be computed and set manually or by assistance of the ACU's automatic calibration function as described below.
Post scale offset	The post scale calibration offset is added to the position value before the angle value is displayed, but after the scaling is applied. The post scale offset is defined in degrees of AZ/EL/POL. The ACU provides a function to calculate and set both, the pre-scale and the post-scale offset from a known pointing:

	1. Set the calibration scale / gear ratio for the axis (this calibration parameter is described with the next paragraph). 2. Set the soft limits of the axis to preliminary values. In most cases this needs not to be very accurate, the ACU needs this information to calculate the pre-scale offset to shift the encoder overflow outside the used range. 3. Optimize the satellite pointing for the reception from a satellite for which the azimuth and elevation values are known. 4. Click to the 'calc' label beside the calibration offset. 5. Enter the known pointing angle for the satellite and click to submit. 6. The ACU calculates and sets the calibration offsets to a value so that the actual pointing is displayed as the angle you entered. For the azimuth axis there is another offset which also is taken into account, the 'Antenna course'. This value is provided for mobile applications where a compass reading has to be included into the azimuth value.
Calibration scale	Normally the ACU assumes that the full range of a position sensor corresponds 360°. If you are using a multiturn position sensor or if the position sensor is mounted to the shaft of a gear rather than to the antenna axis directly, the position sensor reading must be scaled. The displayed angle is computed as follows: *displayed-value = ((raw-reading+pre-scale-offs) * scale) + pos-scale-offs* Mathematically a scale value of 1.0 disables the scaling. Beside this, the ACU also accepts the special value 0 to disable scaling at all. If you set 1.0, the ACU performs the scaling with this factor. With the value 0 the scaling is skipped completely, including the conversion of the reading to floating point. This ensures, that the full accuracy is retained in cases where no scaling is necessary.
Sense invert	With this parameter you easily can reverse the sense of a position sensor. The sense should be as follows: • Azimuth: The antenna looks more to the west for larger values. • Elevation: Larger values mean higher elevation. • Polarization: The feed turns clockwise (when looking through the antenna to the satellite) for increasing values. When operated on the southern hemisphere, the polarization sense must be set the other way round.
Motor driver type	The ACU knows two different configuration modes to control a motor driver. They are called DIR-START and DUAL-START. In DIR-START mode, the FWD signal switches the motor on/off, the REV signal controls the motor direction. This is the configuration many frequency inverters use. In DUAL-START mode, the FWD signal switches the motor on in forward direction, REV activates the motor in reverse direction. This configuration mode is convenient to control a motor with relays. Beside the modes DIR-START and DUAL-START you may set the motor driver type to NONE which prevents the ACU from controlling the motor at all.
Low speed threshold	The ACU controls a motor at two speeds. If the actual position is far away from the target value, the ACU commands the motor to use the fast speed. Once the antenna comes close to the target value, the ACU slows down the motor. The low speed threshold sets the angle deviation which lets the ACU use the fast motor speed.
Pointing hysteresis	The ACU performs the motor control as a closed loop: if the angle reading and the target value differ, the motor is switched on to compensate the difference. If the difference is less than the hysteresis value, the ACU leaves the motor switched off. This prevents the antenna from oscillating around the target value.
Motor timeout	The ACU monitors the position readings while the motor is running. If there is no change in the position readings for some time, the ACU assumes to motor to be blocked and switches it off. This 'motor timeout' fault must be reset by the operator to release it. A timeout value 0 disables the timeout.
Lower limit	The minimum target value accepted at the user interface and via remote control. This software limit prevents the ACU from running the antenna to the limit position under normal conditions.

Upper limit	The maximum target value accepted at the user interface and via remote control. This software limit prevents the ACU from running the antenna to the limit position under normal conditions.

Beacon Receiver

Parameter Name	*Description*
Beacon RX type	Selects the source of the beacon level the ACU shall use. Available options are SATNMS and VOLTAGE. In SATNMS mode the ACU reads the beacon level from a ***sat-nms*** beacon receiver via UDP, in VOLTAGE mode the A/D converter input of the ACU is read. Please mention, that in SATNMS mode, the beacon receiver must be set to send UDP datagrams to the ACU/ODM.
Beacon RX IP address	The IP address of the beacon receiver. Applicable only in SATNMS mode.
Beacon RX voltage scale	The scale factor for the analog beacon level input. The value must match the scaling of the beacon level signal.
Beacon RX 0V level	The beacon level which is displayed if the ACU recognizes 0V beacon level input.

Location

Parameter Name	*Description*
GPS receiver type	Defines the type of GPS receiver the ACU uses to read its geodetic location. 'NONE' tells the ACU that no GPS receiver is connected. The geodetic position of the Antenna has to be entered manually. The ACU synchronized its internal clock to the CMOS clock chip on the board. 'NMEA' tells the ACU to expect messages from a NMEA GPS receiver connected to the serial interface at CON8, pins 1-3. The ACU automatically sets the antenna's geodetic location to the values received and synchronizes the clock to the GPS timestamps. If no NMEA messages are received, the ACU states a fault.
Antenna course	The Antenna course is an additional offset which is included into the azimuth calibration. It is used for mobile antennas to set the orientation of the antenna without recalibrating it. For stationary antennas this value always should be set to 180°.
Antenna longitude	The geodetic longitude of the antenna. For a precise orbit to pointing calculation this value should be entered with 0.001° accuracy.
Antenna latitude	The geodetic latitude of the antenna. For a precise orbit to pointing calculation this value should be entered with 0.001° accuracy.
Antenna abs. altitude	The absolute altitude over sea of the antenna location.

Orientation

Parameter Name	*Description*
Compass type	Applicable only for car-mobile variants of the ACU
Inclinometer type	Applicable only for car-mobile variants of the ACU
Nick offset	Applicable only for car-mobile variants of the ACU
Roll offset	Applicable only for car-mobile variants of the ACU

SNMP Control

From Software version 2.1.007 or higher, the ***sat-nms*** ACU contains an SNMP agent listening at UDP port 161. The SNMP agent provides a common subset of the MIB-II system / interface parameters and gives full access to the remote control capabilities of the ***sat-nms*** ACU with a number of MIB objects placed in the private.enterprises tree.

The actual MIB file defining the ACU's private MIB may be downloaded from the ACU itself by FTP (user 'service', password 'service'). The file 'ACUODM.MIB' contains all necessary information.

Parameter Name	*Description*
SNMP read community	Sets the SNMP community string expected for read access. The default is 'public'.
SNMP write community	Sets the SNMP community string expected for write access. The default is 'public'.
SNMP trap community	Sets the SNMP community string sent with traps. The default is 'public'.
SNMP traps	This parameter decides if the SNMP traps are enabled or disabled.
SNMP system name	The ACU replies to MIB-II sysName requests with the text entered at this place.
SNMP system location	The ACU replies to MIB-II sysLocation requests with the text entered at this place
SNMP system contact	The ACU replies to MIB-II sysContact requests with the text entered at this place.
MIB File	click here to download the MIB file
SNMP trap IP 1-4	Enter up to 4 trap destination IP addresses (dotted quad notation) to make the ACU sending traps by UDP to these hosts. Setting the parameter to 0.0.0.0 disables the trap generation.

Access Control

User password	Here you can define the password for the 'user' login. Default password is 'user'. When you are logged in as 'user' you can command the antenna pointing, set the tracking parameters (if applicable) and store / recall targets. You can't modify the setup parameters or issue low level commands on the test page while logged in as 'user'.
Admin password	Here you can define the password for the 'admin' login. Default password is 'admin'. When you are logged in as "admin" you have full access to all parameters of the ACU, including the setup and the tweaks on the test page.

General				
Note	3.7m Antenna		Date / time	2011-05-16 12:30:56
Display refresh	1 sec			
Axes control mode	PARALLEL		RS485 address	TERM
Azimuth				
AZ Antenna diameter	3.7 m		Az. step delta	0.020 °
AZ Position sensor type	RESOLVER		AZ Motor driver type	DIR-START
AZ Sense invert	NORMAL		AZ Motor timeout	4000 msec
AZ Pre scale offset	FE9CE38F	calc.	AZ Post scale offset	180.000 °
AZ Calibration scale	0.000000		AZ Pointing hysteresis	0.025 °
			AZ Low speed threshold	2.0 °
AZ Lower limit	148.000 °		AZ Upper limit	230.000 °
Elevation				
EL Antenna diameter	3.7 m		El. step delta	0.100 °
EL Position sensor type	RESOLVER		EL Motor driver type	DIR-START
EL Sense invert	INVERTED		EL Motor timeout	4000 msec
EL Pre scale offset	AF29E38F	calc.	EL Post scale offset	45.000 °
EL Calibration scale	0.000000		EL Pointing hysteresis	0.025 °
			EL Low speed threshold	2.0 °
EL Lower limit	8.000 °		EL Upper limit	77.000 °
Polarization				
PO Position sensor type	RESOLVER		PO Motor driver type	DUAL-START
PO Sense invert	NORMAL		PO Motor timeout	4000 msec
PO Pre scale offset	00000000	calc.	PO Post scale offset	20.026 °
PO Calibration scale	0.000000		PO Pointing hysteresis	0.100 °
			PO Low speed threshold	2.0 °
PO Lower limit	-80.000 °		PO Upper limit	111.000 °
Beacon Receiver				
Beacon RX type	SATNMS		Beacon RX IP address	192.168.2.78
Beacon RX voltage scale	n/a		Beacon RX 0V level	n/a
Beacon RX frequency	11450.529 MHz			
Location				
GPS receiver type	NONE		Antenna longitude	8.915 °E
Antenna course	180.000 °		Antenna latitude	47.782 °N
			Antenna abs. altitude	450 m
Orientation				
Compass type	NONE		Inclinometer type	NONE
Nick offset	n/a		Roll offset	n/a
SNMP Control				
SNMP read community	public		SNMP system name	ACU24
SNMP write community	private		SNMP system location	Default
SNMP trap community	public		SNMP system contact	SatService GmbH
SNMP traps	ENABLED		MIB File	ACUODM.MIB
SNMP trap IP 1	192.168.2.18		SNMP trap IP 2	192.168.2.14
SNMP trap IP 3	0.0.0.0		SNMP trap IP 4	0.0.0.0
Access Control				
User password	******		Admin password	******

Setup Page Example

5.7 Handheld Terminal

The antenna may be moved by means of the optional handheld controller. The Handheld function is not yet available at ACU-RMU and ACU19 Version.

Startup

Set parameter 'RS485 address' on the ACUs Setup-page to 'TERM'. This enables communication between the ACU and the ***sat-nms*** handheld.

Connect the Handheld with the provided cable (Handheld: 9pol DSUB + Power supply, ACU-Cabinet: 15pol DSUB). After connecting the Handheld, push the Redraw button once. The start-up screen, that shows the installed software version is displayed for a few seconds. After that the menu for controlling the antenna is displayed automatically.

Operation

STOP	Emergency STOP, stops all Motors immediately, it has to be released by pushing the -button
RESET	Releases the motor-lock that was set by pushing the STOP-button.
REDRAW	Back to start screen
POL CCW	Turns the polarisation counterclockwise
STEP SIZE	Selects the step-size: small steps: x°/keypress (x is the value that was set on the setup-screen), large steps: 10*x°/keypress, continuous mode: the antenna moves as long until the -button is pushed or a limit switch or limit value is reached.
POL CW	Turns the polarisation clockwise
↑	Moves the antenna up (EL)
←	Moves the antenna to the left (AZ)
HALT	Stops the antenna movement (only in continuous mode)
→	Moves the antenna to the right (AZ)
↓	Moves the antenna down (EL)

6 Frontpanel operation

The ***sat-nms*** ACU-ODM and ACU-ODU do not provide frontpanel operation. For these units, we provide an optional handheld for local controlling and monitoring without a laptop. Please refer to chapter 5.7 Handheld Terminal for more informations.

7 Remote Control

The ***sat-nms*** ACU may be controlled remotely by a monitoring and control application either through the TCP/IP interface or through a serial RS232 interface (RS232 not yet implemented in ACU19 and ACU-RMU). Both communication methods use the same commands and parameters. However, there are different frames around each message depending communication method used.

Controlling the device from the web interface, the TCP/IP remote control interface or via the serial interface is completely equal, commands may sent to any interface at any time, the ACU will use the parameter it receives last.

7.1 General command syntax

The ACU knows a number of parameters, each identified by a parameter name. To set a certain parameter to a new value, a message:

name=value

has to be sent to the ACU. The ACU interprets this command, checks the range of *value*, sets the internal parameter and then answers:

name=value

The *value* in the reply is the value actually recognized by the ACU. For instance, if the requested value was out of range, the replied (and internally used) value is limited to the applicable minimum or maximum.

To read a parameter from the ACU, instead of a new parameter value a question mark is sent:

name=?

The ACU replies the actual value in a complete message:

name=value

A complete list of the parameter the ACU knows is shown later in this document in chapter Parameter list. Below, some common rules applying to the remote control message syntax are summarized.

- Parameter names always are of lower case letters, most of them are four characters long.
- Non-numeric parameter values always are written in upper case.
- Numeric (floating point) values may be specified with an arbitrary precision, however the device will reply only a fixed number of places. The ACU recognizes a decimal point ('.'), numbers must not contain any commas.
- There must not be any whitespace in front or after the '=' in a message.
- If the command/query is not of the form **name=value** or **name=?**, the ACU replies the message **? SYNTAX**.
- If the message syntax is OK, but contains an unknown parameter name is used, the reply is **? UNKNOWN**
- Numeric parameters are cut to the limits defined for this particular parameter.
- Misspelled choice values cause the ACU to set the first value of the choice list.
- Assigning a value to a read-only parameter will cause no fault, however the ACU will overwrite this parameter immediately or some seconds later with the actual value.

7.2 The TCP/IP remote control interface

Controlling the ACU through the network is done by means of HTTP GET requests. Setting parameter values or querying readings or settings, all is done by requesting HTTP documents from the ACU. The message *to* the ACU thereby is coded into the URL as a CGI form parameter. The ACU replies a one line document of the MIME type 'text/plain'.

The document name for remote control is **/rmt**, hence (assuming the ACU is listening to the IP address 10.0.0.1), requesting a document with the URL

http://10.0.0.1/rmt?levl=?

Will let the ACU reply the actual beacon level in a one line text document:

levl=-52.31

This way all parameters may be queried or set, you may use your favorite web browser to try out the remote control of the ACU manually.

7.3 The RS232 remote control interface

Beside the network interface, the ACU also provides an RS232 serial port which can be used to control the device remotely. Depending on the device address set, the ACU either runs framed protocol with start/stop characters and checksum or it provides a dumb terminal interface. The RS232 interface always operates at 9600 baud, no parity, 8 data bits, one stop bit.

This interface is not yet implemented in the ACU19 and ACU-RMU! At these versions, you have to select 'NONE' to enable the function of optional frontpanel display and keyboard. If another setting is selected, an optional frontpanel and keyboard has no function.

If an address 'A' .. 'G' is selected, the ACU expects each message it receives to be packed into a frame as described below.

char #	*example*	*description*
1	{	start character, always '{'
2	A	device address (A..G)
3	l	first character of the message body
.	e	message body ...
.	v	..
.	l	..
.	=	..
n-1	?	last character of the message body
n	}	end character, always '}'
n+1	.	checksum

The checksum byte is calculated using an algorithm as implemented by the following formula:

$$sum = 32 + \left(\sum_{i=1}^{n} (byte[i] - 32) \right) \text{ modulo } 95$$

This protocol type is known as *MOD95-* or *Miteq protocol*. The ACU also packs its reply in a protocol frame as described above. Incomplete frames, checksum errors or address mismatches let the ACU ignore the message. The time between the characters of a message must be less than 5 seconds or the ACU will treat the message as incomplete.

If the ACU is set to the device address 'NONE', it uses a simple line protocol instead of the framed protocol described above. Messages sent to the ACU have to be terminated with a carriage return character (ASCII 13), the ACU terminates replies with a CR/LF pair (ASCII 13/10). There is no echo for characters entered, hence this protocol easily may be used for computer based remote control.
This setting is also used for allowing communication to an optional frontpanel display and keyboard if implemented.

If 'TERM' is selected the serial interface is used to allow communication between the ACU and a ***sat-nms*** Handheld. This function is not available at ACU-RMU and ACU19 Version.

7.4 Parameter list

The table below shows the complete list of M&C parameters the ACU knows in alphabetical order. For each parameter the valid range and a short description is given.

name		*range*	*unit*	*description*
aabw	r/o		°	AZ antenna 3dB beamwidth
aalt		0 .. 8000	m	Antenna abs. altitude
aamp	r/o		%	AZ Amplitude
acal		-360.000 .. 360.000	°	AZ Calibration offset
aclc			°	Calculate offset from Az. value
acoe	r/o	see below	-	AZ model coefficients
acou		-180.000 .. 180.000	°	Antenna course
addr		A B C D E F G NONE	-	RS485 address
ahys		0.000 .. 2.000	°	AZ Pointing hysteresis
ainv		NORMAL INVERTED	-	AZ Sense invert
ajtr	r/o		%	AZ Peaking jitter
alat		0.000 .. 90.000	°N	Antenna latitude
alon		-180.000 .. 180.000	°E	Antenna longitude
amax		180.000 .. 360.000	°	AZ Upper limit
amdt	r/o	character string		AZ Model type
amin		0.000 .. 180.000	°	AZ Lower limit
ammx		SMALL MEDIUM LARGE	-	AZ Maximum model type
amnt		AZ-OVER-EL POLAR	-	Antenna mount type
amot		DUAL-START DIR-START NONE	-	AZ Motor driver type
apos	r/o	-180.000 .. 180.000	°	AZ Pointing
araw	r/o	00000000 .. FFFFFFFF		AZ raw pointing
asca		0.000000 .. 100000.000000		AZ Calibration scale
asen		SSI-13B SSI-13G SSI-17B SSI-17G SSI-18B SSI-18G SSI-19B SSI-19G SSI-20B SSI-20G SSI-24B SSI-24G RESOLVER VOLTAGE NONE	-	AZ Position sensor type

asth		0.0 .. 10.0	°	AZ Low speed threshold
astp		0.000 .. 90.000	°	AZ Step delta
atar		-180.000 .. 180.000	°	Az. target value
atot		0 .. 32000	msec	AZ Motor timeout
atsz	r/o		°	AZ tracking step size
axmd		PARALLEL SEQUENTIAL	-	Axes control mode
bavg		1 .. 25	samples	Level averaging
bcfr		1000.000 .. 40000.000	MHz	Beacon RX frequency
bcip		aaa.bbb.ccc.ddd		Beacon RX IP address
bcof		-200.00 .. 0.00	dBm	Beacon RX 0V level
bcsc		-5.0000 .. 5.0000	V/dB	Beacon RX voltage scale
bcty		SATNMS VOLTAGE	-	Beacon RX type
blev	r/o	#.##	dBm	Beacon level
brip	r/o	#.##	dB	Beacon level ripple
btrh		-999.00 .. 100.00	dBm	Level threshold
caps	r/o	00 .. FF		Software capabilities 1)
coty		NONE	-	Compass type 2)
decl		-90.000 .. 90.000	°	Antenna declination
dele		0 .. 99		Delete target
diaa		0.0 .. 100.0	m	AZ Antenna diameter
diae		0.0 .. 100.0	m	EL Antenna diameter
eabw	r/o		°	EL antenna 3dB beamwidth
eamp	r/o		%	EL Amplitude
ecal		-360.000 .. 360.000	°	EL Calibration offset
eclc			°	Calculate offset from El. value

ecoe	r/o/	see below		EL model coefficients
ehys		0.000 .. 2.000	°	EL Pointing hysteresis
einv		NORMAL INVERTED	-	EL Sense invert
ejtr	r/o	0 ..	%	EL Peaking jitter
emax		0.000 .. 90.000	°	EL Upper limit
emdt	r/o	character string		EL Model type
emin		0.000 .. 90.000	°	EL Lower limit
emmx		SMALL MEDIUM LARGE	-	EL Maximum model type
emot		DUAL-START DIR-START NONE	-	EL Motor driver type
epos	r/o	0.000 .. 90.000	°	EL Pointing
eraw	r/o	00000000 .. FFFFFFFF		EL raw pointing
esca		0.000000 .. 100000.000000		EL Calibration scale
esen		SSI-13B SSI-13G SSI-17B SSI-17G SSI-18B SSI-18G SSI-19B SSI-19G SSI-20B SSI-20G SSI-24B SSI-24G RESOLVER VOLTAGE NONE	-	EL Position sensor type
esth		0.0 .. 10.0	°	EL Low speed threshold
estp		0.000 .. 90.000	°	EL Step delta
etar		0.000 .. 90.000	°	El. target value
etot		0 .. 32000	msec	EL Motor timeout
etsz	r/o		°	EL tracking step size
goto		0 .. 99		Goto target
gpty		NONE	-	GPS receiver type 3)
ibit		00000000 .. FFFFFFFF		Input bits (described below)
icty		NONE	-	Inclinometer type 4)
jtrh		0 .. 100	%	Peak jitter threshold
mdly		0 .. 9999	msec	Measurement delay
mstp		0 .. 1		1 stops all motors

				(STOP at the Web UI) 0 releases the stop (RESET at the Web UI)
nick	r/o	-90.0 .. 90.0	°	Nick angle
niko		-90.0 .. 90.0	°	Nick offset
note		character string		Note
obit		00000000 .. FFFFFFFF		Output bits (described below)
orbt		-180.000 .. 180.000	°E	Orbit position
pcal		-360.000 .. 360.000	°	PO Calibration offset
pclc			°	Calculate offset from Pol. value
pcnt		0 .. 65535		Peak count
phys		0.000 .. 10.000	°	PO Pointing hysteresis
pinv		NORMAL INVERTED	-	PO Sense invert
pmax		0.000 .. 180.000	°	PO Upper limit
pmin		-180.000 .. 0.000	°	PO Lower limit
pmot		DUAL-START DIR-START NONE	-	PO Motor driver type
ppos	r/o	-90.000 .. 90.000	°	PO Pointing
praw	r/o	00000000 .. FFFFFFFF		PO raw pointing
psca		0.000000 .. 100000.000000		PO Calibration scale
psen		SSI-13B SSI-13G SSI-17B SSI-17G SSI-18B SSI-18G SSI-19B SSI-19G SSI-20B SSI-20G SSI-24B SSI-24G RESOLVER VOLTAGE NONE	-	PO Position sensor type
psth		0.0 .. 10.0	°	PO Low speed threshold
pstp		0.000 .. 90.000	°	PO Step delta
ptar		-90.000 .. 90.000	°	Pol. target value
ptot		0 .. 32000	msec	PO Motor timeout
pwda		character string	*	Admin password
pwdu		character string	*	User password

roll	r/o	-90.0 .. 90.0	°	Roll angle
rolo		-90.0 .. 90.0	°	Roll offset
save		0 .. 99		Save target
scnt	r/o	0 .. 65535		Save count
slee	r/o	0 .. 65535	sec	Sleep time up to the next tracking action
smth		0 .. 6	h	Smoothing interval
srno	r/o	character string		Device serial no
step		command		Step move 5)
stim		character string		Date / time 6)
sver	r/o	character string		Software version
tage	r/o	#.#	h	Tracking model age
tcyc		1 .. 1638	sec	Tracking cycle time
tdly		100 .. 9999	msec	Recovery delay
temp	r/o	#.#	°C	Temperature
tdsc		0..99 / character string	°C	Target description 7)
tflt	r/o	00 .. FF		Tracking fault bits (described below)
thrs	r/o	#.#	h	Tracking memory
time	r/o	character string		Date / time 6)
tlog		1 .. 1		Log to tracking memory
tmod		OFF STEP ADAPTIVE MEMORY PROGRAM	-	Tracking mode 8)
trty		NEVER ONCE FOREVER		Tracking retry on fault
tnam		character string		Target name
trst		1 .. 1		Reset tracking memory
trty		NEVER ONCE FOREVER		Tracking retry on fault
tsta	r/o	character string		Tracking state
tstp		1 .. 100	%	Tracking step size

wdog		OFF ON		ON Sends a heatbeat to the AUX 8 output

Remarks:

1) Software capabilities are summed from the following values:
1 = step track & adaptive tracking included
2 = polar mount antennas supported
4 = memory tracking ingluded
2) ACU variants with compass support provide other choices beside NONE for this parameter.
3) ACU variants with GPS support provide other choices beside NONE for this parameter.
4) ACU variants with inclinometer support provide other choices beside NONE for this parameter.
5) for single step move, use following commands:

command	*description*
ll	Azimuth large step left
l	Azimuth small step left
r	Azimuth small step right
rr	Azimuth large step right
dd	Elevation large step down
d	small step down
u	small step up
uu	large step up
c	Polarisation clockwise step
cc	Polarisation counter clockwise step

6) Use the 'time' parameter to read the actual time used by the ACU. Use the 'stim' parameter to set the time.
7) This parameter reports the description (name and pointing angles) for a given target number. 'tdsc=12' e.g. is interpreted by the ACU as a request to report the target description for target no. 12. The reply to this command is something like 'tdsc=ASTRA 19.2 (167.335/43.412/-15.455)'
8) ACU variants without tracking support only accept NONE for this parameter.

Bit definitions in 'ibit' (input bits and flags):

The 'ibit' value is returned as a 32 bit hexadecimal number. The bit number 0 means the least significant bit, bit number 31 the most significant bit in this number.

no.	*name*	*description*
0	IN_PLHLM	polarization hi limit
1	IN_PLLLM	polarization lo limit
2	IN_PLFLT	polarization motor fault
3	IN_HBFLT	antenna hub fault
4	IN_AUX1	reserved
5	IN_AUX2	reserved
6	IN_AUX3	reserved
7	IN_AUX4	reserved
8	IN_AZHLM	azimuth hi limit
9	IN_AZLLM	azimuth lo limit
10	IN_AZFLT	azimuth motor fault
11	IN_EMERG	emergency stop

12	IN_ELHLM	elevation hi limit
13	IN_ELLLM	elevation lo limit
14	IN_ELFLT	elevation motor fault
15	IN_COPEN	cabinet open
16	AZMOV	azimuth moving
17	ELMOV	elevation moving
18	PLMOV	polarization moving
19	MOVING	moving summary bit
20	AZTOT	azimuth timeout
21	ELTOT	elevation timeout
22	PLTOT	polarization timeout
23	TIMEOUT	timeout summary bit
24	TRKPEAK	peaking in progress
25	LOWBEAC	low beacon signal
26	BCRXFLT	beacon receiver fault
27	LIMIT	limit switch summary
28	AZSTOP	azimuth stopped
29	ELSTOP	elevation stopped
30	PLSTOP	polarization stopped
31	GPSFLT	GPS receiver fault

Bit definitions in 'obit' (output bits):

The 'obit' value is returned as a 32 bit hexadecimal number. The bit number 0 means the least significant bit, bit number 31 the most significant bit in this number.

no.	*name*	*description*
0	OUT_AZ_FWD	azimuth motor forward
1	OUT_AZ_REV	azimuth motor reverse
2	OUT_AZ_SPD1	azimuth motor low speed
3	OUT_AZ_SPD2	azimuth motor hi speed
4	OUT_AZ_RESET	azimuth motor driver reset
5	OUT_AZ_RESERVE	reserved for extended motor control
6	OUT_AUX1	not used
7	OUT_AUX2	not used
8	OUT_EL_FWD	elevation motor forward
9	OUT_EL_REV	elevation motor reverse
10	OUT_EL_SPD1	elevation motor low speed
11	OUT_EL_SPD2	elevation motor hi speed
12	OUT_EL_RESET	elevation motor driver reset
13	OUT_EL_RESERVE	reserved for extended motor control
14	OUT_AUX3	not used
15	OUT_AUX4	not used
16	OUT_POL_FWD	polarization motor forward
17	OUT_POL_REV	polarization motor reverse
18	OUT_POL_SPD1	polarization motor low speed

19	OUT_POL_SPD2	polarization motor hi speed
20	OUT_POL_RESET	polarization motor driver reset
21	OUT_POL_RESERVE	reserved for extended motor control
22	OUT_AUX5	not used
23	OUT_AUX6	not used
24	OUT_SUMMARY	summary fault relay (1 == OK)
25	OUT_TRACKING	tracking fault relay (1 == OK)
26	OUT_BCPR1	reserved for beacon receiver frequency select
27	OUT_BCPR2	reserved for beacon receiver frequency select
28	OUT_BCPR3	reserved for beacon receiver frequency select
29	OUT_BCPR4	reserved for beacon receiver frequency select
30	OUT_AUX7	not used
31	OUT_AUX8	not used

The meaning of the 'FWD' / 'REV' motor control outputs depend on the motor control mode set for this axis.

Bit definitions in 'tflt' (tracking faults):

The 'tflt' value is returned as a 8 bit hexadecimal number. The bit number 0 means the least significant bit, bit number 7 the most significant bit in this number.

no.	*name*	*description*
0	APEAKFLT	azimuth peaking fault
1	EPEAKFLT	elevation peaking fault
2	MODELFLT	model match fault
3	JITTRFLT	jitter fault
4	-/-	not used
5	-/-	not used
6	-/-	not used
7	-/-	not used

Tracking coefficients on 'acoe' / 'ecoe':

In adaptive tracking mode the 'acoe' / 'ecoe' commands may be used to read the coefficients of the actual model. The coefficients are returned as a comma separated list of numbers in scientific notation. The number o f coefficients returned depends on the size of the model:

SMALL: *a0,a1,a2* (1)
MEDIUM: *a0,a1,a2,a3,a4* (2)
LARGE: *a0,a1,a2,a3,a4,a5* (3)

If the beacon signal drops below it's theshold, the antenna movement is calculated from these coefficients using the formulas shown below:

$$\alpha_{small} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) \quad (1)$$

$$\alpha_{medium} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) + a_3 \cos(2\omega t) + a_4 \sin(2\omega t) \quad (2)$$

$$\alpha_{large} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) + a_3 \cos(2\omega t) + a_4 \sin(2\omega t) + a_5 t \quad (3)$$

7.5 One line read via TCP/IP

For compatibility with the ***sat-nms*** power sensor, the ACU also may be polled for an automated monitoring

by the requesting the 'position' document with a HTTP GET command. Assuming the ACU listens to the IP address 10.0.0.1, the complete URL for the request is:

http://10.0.0.1/point?fmt=txt

The 'fmt=txt' parameter forces the power sensor to reply a one line text document rather than the HTML coded page which is normally displayed by the web browser.

The ACU answers a 'text/plain' type document which consists of one line. As shown in the example below, the line consists of a set of keyword - value pairs, separated by '&' characters. Within each pair, keyword and value are separated by the '=' character.

apos=174.688&epos=31.456&ppos=-34.5&atar=174.700&etar=31.500&ptar=-34.5&blev=-64.33&temp=63.5&obit=FFFF0000&ibit=FFFF0000&

The format does not use fixed column widths for the values, however the precision of floating point values is always as shown in the example. An application which parses this string should not rely on the order of the values in the line. Future version of the ACU may provide additional values which not necessarily will appear at the end of the line. A description of the parameters is given in the chapter Parameter list above.

8 Theory of Operation

This section gives some background information about how the ACU works.

Chapter 8.1 Angle Measurement describes how the ACU measures the antenna pointing and how it calculates the angles displayed at the user interface.

Chapter 8.2 Pointing / Motor Control describes the way the ACU performs the antenna pointing and how it controls the motors.

Chapter 8.3 Steptrack describes the step track method used by ***sat-nms*** ACUs providing this function.

Chapter 8.4 Adaptive Tracking describes the adaptive (orbit prediction) tracking method used by ***sat-nms*** ACUs providing this function.

Chapter 8.5 Program Tracking describes the program / file tracking capability built into the ***sat-nms*** ACU.

8.1 Angle Measurement

The ***sat-nms*** ACU provides exchangeable interfaces for several types of position sensors. Position sensor interfaces may be selected individually for each axis. This gives a maximum of flexibility for application where the ***sat-nms*** ACU replaces an existing antenna controller.

Position sensor types

Actually there are three types of position sensor interfaces available for the ACU. The interfaces principally are field-replaceable, however changing interface boards inside the ACU should be done by skilled personnel only. ESD protection must be followed when handling the ACU boards. The ACU is capable to interface to the following types of positional sensors:

SSI	SSI type digital position encoders are the first choice for antennas which are setup from scratch. They are precise, reliable and provide a standardized interface. The ACU supports types from 13 to 24 bit resolution, both, gray coded and binary variants. The ACU provides 5V and 24V supply voltages (200mA max) for the encoders, so external power supplies may be omitted in most cases.
RESOLVER	Many existing antennas are equipped with resolvers. The resolver interface module permits to re-use these ready mounted and cabled sensors when an old antenna controller is to be replaced by a ***sat-nms*** ACU. The resolver interface board is optimized for the use with 2V type resolvers which are very common. The interface board drives the resolver with 4Veff / 2000Hz and expects 2Veff at the sin/cos inputs. The resolver interface has 16 bit binary resolution.
ANALOG	For small antennas with reduced accuracy requirements using analog angle to voltage sensors (in fact precision potentiometers) is an inexpensive alternative. The analog sensor interface board may be set up for several voltages to connect to the commonly used sensor types. The analog interface board uses a 16 bit precision ADC with a temperature compensated voltage reference.

Angle calibration

Analogous to the modular position interface hardware concept, the ACU software uses configurable drivers to read the different types of position interfaces. From the user's point of view, the ACU accepts and displays pointing angles as floating point numbers with 0.001° resolution. Internally the software treats angles as 32 bit integer numbers where the full 32 bit range corresponds to 360°. This is equivalent to a resolution of 0.000000084°.

When the software calculates the pointing angles from the sensor readings, it includes some calibration parameters configurable at the Setup page. The steps of calculating a pointing angle are as follows:

1. Get the raw value.
2. Extend (left shift) the value to 32 bits.
3. Reverse the sign if this option is set in the setup.
4. Apply (add) the pre-scale offset.

5. Convert to degrees.
6. If the calibration scale is nonzero, multiply by the calibration scale.
7. Add the post scale calibration offset.
8. For the azimuth axis add the antenna course, too.

The angle calculated this way may exceed a full circle of 360° if the scaling ensures that there is no overflow of the encoder reading itself. The value displayed as raw reading at the test page, is the result of step 2.

8.2 Pointing / Motor Control

The ***sat-nms*** ACU performs the pointing / motor control as a closed control loop, independently for each axis. If the measured position value differs from the target value, the motor is activated to compensate this difference. It makes no difference if a new target value has been commanded or if the antenna has moved a little bit due to a squall.

Hysteresis

To avoid that the motor is switched forth and back all the time, the ACU tolerates small differences between measured and target value within a hysteresis value. This hysteresis is individually configurable for each axis at the Setup page. To ensure that the motor stands still when the target position is reached, twice the resolution (step size) of the position sensor / encoder must be set. Common values are:

bit resolution	*angular resolution*	*recommended hysteresis*
13 bit	0.044°	0.090°
16 bit	0.005°	0.012°
17 bit	0.003°	0.006°

If the motor control loop still oscillates with the recommended hysteresis values, this is due to the off-carriage of the antenna drive. Either turn down the motor speed at the motor driver unit or enlarge the hysteresis value in this case.

Motor drive signals

The ***sat-nms*** ACU-ODM, the core module, provides a number of output signals to control a motor driver unit. These signals (they are available for all three axes) are:

FWD	Depending on the motor driver type configured, this signal generally switches the motor on for both directions or for the forward direction only.
REV	Depending on the motor driver type configured, this signal reverses the motor direction or it activates the motor in reverse direction.
SPD1	This signal is active while the ACU wants to run the motor slowly.
SPD2	This signal is active while the ACU wants to run the motor fast.
RESET	The ACU activates this signal for 800 msecs if the operator clicks RESET. The signal may be cabled to an input of the motor driver which resets latching faults.
FAULT	The ACU monitors this signal all the time. The signal is low-active, i.e. the ACU expects current flowing through the optocoupler while the driver is OK, if the circuit is opened, the ACU signals a fault and stops the motor. If the motor driver does not provide a fault signal, the clamps of the FAULT input must be wired to 0V/24V otherwise the ACU will not move the motor!

The ACU knows two different configuration modes to control a motor driver. They are called 'DIR-START' and 'DUAL-START'. In 'DIR-START' mode, the 'FWD' signal switches the motor on/off, the 'REV' signal controls the motor direction. This is the configuration many frequency inverters use. In 'DUAL-START' mode, the 'FWD' signal switches the motor on in forward direction, 'REV' activates the motor in reverse direction. This configuration mode is convenient to control a motor with relays.

The speed select signal SP1 and SPD2 actually are the same signal, but with different logical polarity. For most motor drivers it is sufficient to connect one of these two signals, select the one which matches the polarity the motor driver expects.

Very important is how the direction of movement is wired. The proper direction depends on if the antenna is operated on the northern or on the southern hemisphere:

axis	*northern hemisphere*	*southern hemisphere*
azimuth	FWD moves the antenna to the right (westward).	FWD moves the antenna to the left (westward).
elevation	FWD moves the antenna up	FWD moves the antenna up
polarization	FWD turns the feed clockwise	FWD turns the feed counterclockwise

Look 'through the antenna' to the satellite for the correct orientation of the left/right/clockwise directions. The sense of the position sensors **must** set that the sensors give increasing values while the antenna moves FWD.

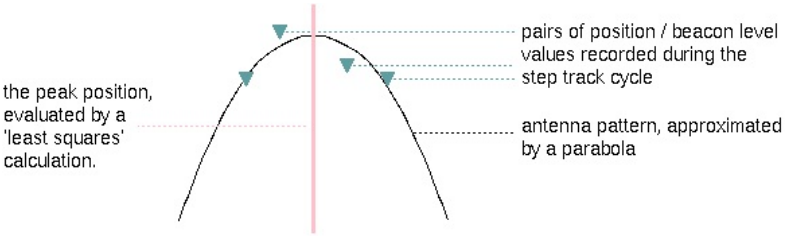
8.3 Steptrack

sat-nms ACUs having the "ACU-ODM Software Upgrade Step Track" installed are capable to track a satellite's position. The following paragraph describes how the ***sat-nms*** steptrack algorithm works. Beside plain step track, this option includes the so called adaptive tracking and a file/program tracking facility as well. While step track and adaptive tracking require a beacon receiver to be connected to the ACU, the file/program tracking works without any beacon measurement.

8.3.1 The *sat-nms* Steptrack Algorithm

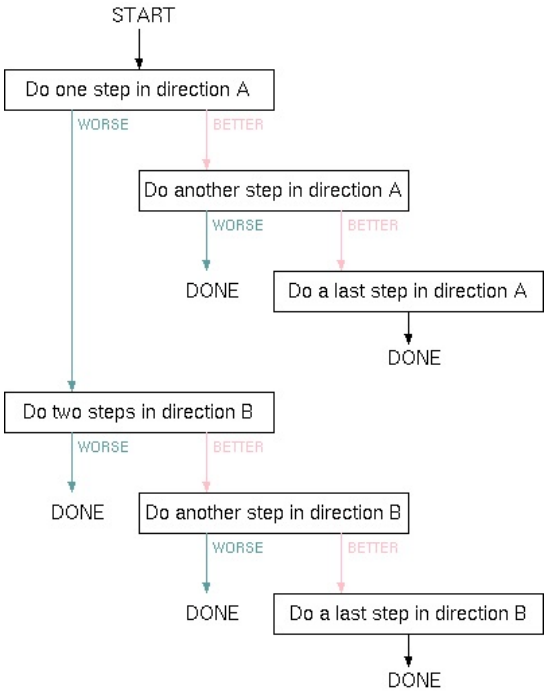
The principle of satellite step tracking is quite simple: For each axis, move the antenna a small amount away from the satellite, move it a small amount to the other site and finally point the antenna to that position where the signal is the strongest. The ***sat-nms*** ACU uses an optimized variant of this method which lets the tracking find the best pointing ('peak') with a minimum amount of depointing.

Within one step track cycle on one axis, the ACU does several very small steps. Using the position and beacon level values of all steps in the cycle, the ACU calculates the peak position by aligning the approximated antenna pattern to the measured points.


pairs of position / beacon level values recorded during the step track cycle
the peak position, evaluated by a 'least squares' calculation.
antenna pattern, approximated by a parabola

This method minimizes the impact of noise and measurement errors to the evaluated peak position. The benefit is, that the size of depointing steps can be reduced to a very small value.

A tracking cycle consists of 2 .. 4 tests steps. With each step the antenna is moved a certain angle increment, the beacon level is measured before and after the movement. The angle increment is an adjustable value, expressed as a percentage of the antenna's 3dB beamwidth. A typical value is 15% of the (half) beamwidth.



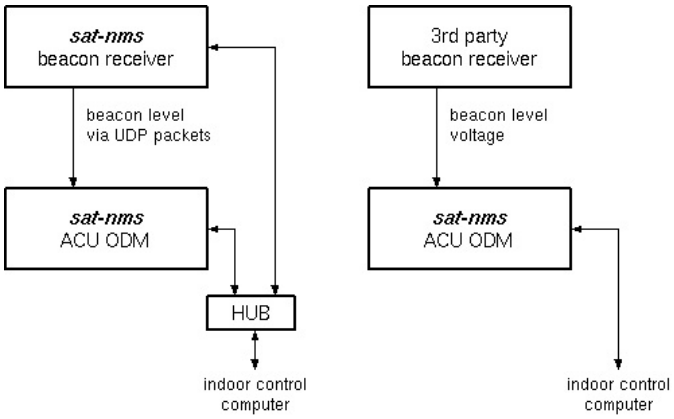
The diagram above shows the sequence of steps the tracking algorithm performs in one cycle on one axis. It starts with a depointing step in one direction (A). If this step lets the signal level decrease, the antenna makes a double step in the opposite direction. It the first step leads to a better receive level, the tracking algorithm adds one or two steps in the same direction.

For a reliable tracking operation the step size have to be big enought to rech the maximum within the 3dB bandwith within in the entered cycle time. This meas for an inclient satellite you need a shorter cycle time than for a geostationary satellite.

8.3.2 ACU and Beacon Receiver

To perform a step track, the ACU requires the actually measured beacon level as a rate of the received signal quality and therefore the closeness of the antenna pointing to the ideal value. The ***sat-nms*** ACU is capable to be operated both with the ***sat-nms*** LBRX beacon receiver and with third party beacon receiver products.

With a third party beacon receiver, the ACU reads the beacon level from an analog voltage input. The beacon receiver therefore must provide a dB-linear output voltage, preferably in the range 0...10V. If the ***sat-nms*** beacon receiver is used, then the beacon level is sent from the beacon receiver to the ACU via UDP packets on the LAN.



If a ***sat-nms*** LBRX beacon receiver is used with the ACU, it additionally gets connected to the ACU through an Ethernet cable. Usually an Ethernet hub is used to connect the ACU, the LBRX and the

controlling computer. With a ***sat-nms*** LBRX beacon receiver some additional features are available for the tracking:

- The beacon receiver sends the actual level as UDP packets over the LAN. The ACU ODM receives this value without any accuracy degrading due to cascaded digital to analog / analog to digital conversions.
- The ACU reads the beacon frequency from the LBRX at the start of each tracking cycle. The value read from the receiver overwrites the value set by the operator and is used to calculate the antenna's beamwidth.
- The ACU informs the ***sat-nms*** LBRX when a tracking cycle starts and when it ends. The LBRX suspends any background activities like noise reference measurements or frequency tracking. This ensures, that the beacon receiver recognizes level differences without a delay during the tracking cycle.

For a well functioning step track with a third party receiver, it is important to adjust the voltage level range to the scale and offset provided by the beacon receiver. If at the beacon receiver these values may be adjusted too, a preferable scale is 0.5V/dB for 20dB usable range. The offset should be adjusted, that the receive level at clear sky conditions leave a headroom of 3dB at the top end of the range. The analog voltage never should reach the physical limit of 0V/10V under normal conditions. Clamping the level voltage probably will misslead the tracking.

8.3.3 Smoothing

The peak positions found by the step track may jitter due to noise. Specially, if an almost stable positioned satellite is tracked with a relatively small antenna, this jitter may be more than the real movement of the satellite. To stabilize the tracking in such situations, the ***sat-nms*** ACU provides a smoothing function which lets you reduce the pointing jitter.

The smoothing function is based in the fact, that most satellites (specially that ones which are on a stable orbit position) require the antenna to follow a small amplitude sine function with 24 hours cycle time in order to track the satellite optimally.

If you activate smoothing by setting the smoothing time to a non zero value, all peak positions of the last *n* hours get averaged by a sine function which matches the measured peaks at the best. After each step track cycle the antenna gets moved to the 'smoothed' position rather than to the recently evaluated peak position.

The usage of the smoothing function is recommended when tracking satellites where the antenna pointing oscillates less than 25% of the antenna's 3dB beamwidth. For tracking inclined orbit satellites, the usage of smoothing may be problematic as such satellites may require an significant position oscillation at 12 hours cycle time (sin 2wt). The smoothing function uses a simple sinusoidal model which does not provide this double frequency component. Hence, applying the smoothing function for such a satellite with more than 3 hours smoothing time may average the antenna movement path too much.

8.3.4 Steptrack Parameters

The behavior of the satellite step track is adjustable with a couple of parameters. This permits to tune the step track performance for special preconditions arising from the antenna and also the satellite. The first parameters listed below are setup parameters, they are set once for an ACU installation to adapt the ACU to the antenna and the beacon receiver.

AZ Antenna diameter **EL Antenna diameter**	The diameter values are used by the ACU software to evaluate the antenna's beamwidth. There are separate values for both axes to handle offset antennas as well.
Beacon RX type	With this parameter you specify which type of beacon receiver. For a ***sat-nms*** LBRX beacon receiver set it to 'SATNMS' and set the receiver's IP address accordingly. To make ACU and beacon receiver work together you should take care of the following: • ACU and beacon receiver must be connected to the same Ethernet segment. • Both devices must have assigned IP addresses in the same subnet. • The LBRX beacon receiver must be configured for the correct LO frequency. The displayed receive frequency must be the true RX frequency rather than the L-band frequency.

	• At the ***sat-nms*** LBRX the ACU's IP address must be set as the 'UDP destination address'. The setting 'VOLTAGE' is used with any other type of beacon receiver or with a ***sat-nms*** LBRX beacon receiver which has no TCP/IP connection to the ACU. When operating in SATNMS mode, the ACU will automatically determine the beacon frequency from the ***sat-nms*** beacon receiver. Also the beacon receiver's background activities like frequency tracking and noise reference measurements get synchronized to the step track sequence in this mode. These features are not available in the VOLTAGE operating mode.
Beacon RX IP address	You need to enter the beacon receiver's IP address in 'dotted quad' notation here if the receiver tape is set to 'SATNMS'.
Beacon RX voltage scale **Beacon RX 0V level**	These parameters define the slope and offset of the beacon level voltage. The values must be set to match settings of the beacon receiver. With the ***sat-nms*** LBRX beacon receiver you can set these parameters there as well, chapter '8.3.2 ACU And Beacon Receiver' explains how to find the best settings for this.

The parameters in the table below are to be set individually for each satellite. They are set at the 'Tracking' page and stored with each target memory.

Beacon RX frequency	This parameter is only of interest if a third party beacon receiver is used. The beacon frequency (you must enter the frequency received by the antenna [MHz], not the IF frequency seen by the receiver.) is used by the ACU to calculate the antenna's beamwidth and an approximated beam pattern. With the ***sat-nms*** LBRX beacon receiver, the ACU automatically reads the frequency from the receiver.
Tracking cycle time	The cycle time specifies how often the ACU shall perform a step track cycle. The value is to be entered in seconds. In fact, the parameter does not specify a cycle time but the sleep time between two tracking cycles. This means, the true cycle time is the time the ACU needs to perform one step track cycle plus the time entered here. 300 seconds (5 minutes) is a good starting value for this parameter. Inclined orbit satellites probably will require a shorter cycle time, very stable satellites can be perfectly tracked with one step track cycle every 15 minutes (900 seconds).
Tracking step size	The tracking step size is a very important parameter for the performance of the tracking. It defines the size of every depointing step, the ACU makes in order to find out where the optimal antenna pointing is. Setting too high values will cause significant signal degradations during the step track cycle because the antenna moves a too large amount away from the satellite. Setting the value too small will let the beacon level jitter mask the level differences caused by the test steps, the antenna will not track the satellite properly. The step size is specified as a percentage of the antenna's half 3dB beamwidth. The ACU calculates the beamwidth from the antenna diameter and the beacon frequency. Expressing the step size in this relative way keeps the value in the same range, regardless of the type of antenna. The recommended value for this parameter is 15-20%. You may want to start with 20% and try to reduce down to 15% if the signal degradation during tracking becomes too high. The tracking step size is a common parameter for both axes. If both axes behave differently, you can tweak the antenna diameter settings in the setup. Specifying a larger diameter makes the ACU using a smaller step size for this axis. If the tracking step seems to be completely out of range, you should check if the beacon frequency is set properly. The frequency must be the true receive frequency at the antenna, entered in MHz, not an L-band frequency or other IF.
Tracking mode	The tracking mode parameter switches the steptrack on or off. With the

	operation modes 'STEP' and 'ADAPTIVE' the ACU performs steptrack.
Level averaging	When measuring the beacon level, the ACU takes a number of samples and averages them. The standard value of 5 samples normally should not be changed. Larger values will slow down the ACU execution cycle.
Level threshold	If the beacon level drops below this value, the ACU raises a fault signal. Steptrack is inhibited while the beacon level is too low, the antenna position freezes.
Recovery delay	After the the ACU has done the tracking steps for the elevation axis, it waits some time before it starts tracking the azimuth axis. This is to let the beacon level settle after the final position has been found. A typical value for this parameter is 4000 msec.
Measurement delay	During a steptrack cycle, the ACU positions the antenna to a certain offset and then measures the level. Between the moment when the antenna reached commanded position and the beacon level measurement the ACU waits some time to let the beacon level settle. The optimal delay value depends on the beacon receiver's averaging / post detector filter setting and is a quite critical for the steptrack performance. If the delay is too short, the beacon voltage does not reach its final value, the steptrack does not properly recognize if the signal gor better or worse after a test step. If the delay is too long, the impact of fluctuation to the measures level grows and may cover the small level difference caused by the test step. With the ***sat-nms*** LBRX beacon receiver, best results are achieved if the receiver is set to 0.5 Hz post detector filter bandwidth and a measurement delay of 1500 msec.
Smoothing interval	This parameter controls the smoothing function. Setting it to zero disables smoothing. A detailed description of this function you find at chapter '8.3.3 Smoothing'

8.4 Adaptive Tracking

Adaptive tracking is an extension to the standard step track method. The ACU records the tracked positions over several days. It computes a mathematical model from the recorded data which is used to predict the antenna position in case of a beacon receive failure. The following paragraphs describe how the ***sat-nms*** adaptive tracking algorithm works.

8.4.1 The *sat-nms* Adaptive Tracking Algorithm

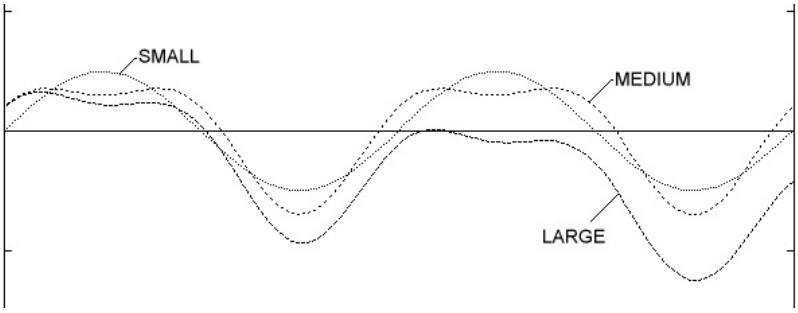
The motion of a geostationary satellite at the sky mainly is caused by an inclination of the satellite's orbit with respect to the earth's equatorial plane, sometimes also by the fact, that satellites decelerate in orbit. The motion seen from the antenna's point of view can be described as the sum of harmonic oscillations with the frequency being multiples of the reciprocal of an sidereal day.

The mathematical models used by the ***sat-nms*** adaptive tracking algorithm to predict the satellite's motion are finite sets of harmonic elements. The coefficients of the elements are evaluated from the step track data recorded for several hours or days by means of the least square fit method.

The more elements are included to a model, the better approximation of the true motion is possible. On the other hand, the number of data points used to evaluate a model is limited, the measurements values are distorted due to inaccuracy and noise. The more complicated a model is, the more susceptible it is to noise. For practical usage, there have to be used varying models, depending on the amount and quality of the recorded steptrack data.

Models

The ACU uses three different mathematical models to describe the movement of the antenna while it tracks the satellite. All models are based on sinusoidal functions with a cycle time on an sidereal day. The models called SMALL, MEDIUM and LARGE differ in their complexity.



The SMALL model, the simplest one, emulates the true antenna movement with a plain sine function. There are only three parameters with this model, the nominal antenna pointing, and the amplitude / phase values of the superposed sine. This model is very stable, gives reliable results even with only a few measured step track peaks.

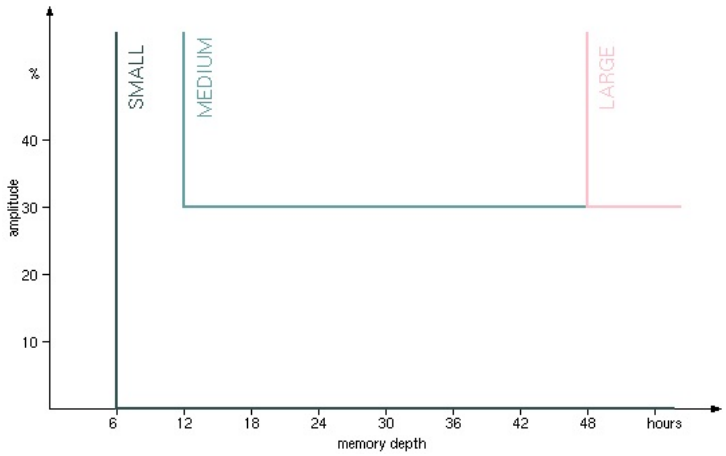
Unfortunately the SMALL model does not fit optimally for all satellites. The MEDIUM model superposes a second sine wave with the double frequency (two cycles for one sidereal day). The model matches very good for almost all stationary satellites. It however requires more and also more precisely measured data points to give reliable results. The MEDIUM model is fully compatible to the SMALL one, this means that also satellites for which the antenna must follow a plain sine function may be tracked with the MEDIUM model. The amplitude of the double frequency sine simply is near zero in such a case.

Finally the LARGE model adds a linear movement to the components of the MEDIUM model. This is required to track significantly inclined satellites over a period of several days. Such satellites tend to drift in their position, the linear movement component can compensate this effect for a couple of days. The LARGE model is the most demanding one concerning the step track data it is based on.

Model selection

The ACU normally by itself selects the adaptive tracking model for each axis individually. The decision which model will be used in case of a beacon drop out is made based on the amount and quality of the data in the tracking memory.

The quality of the recorded data mainly depends on the amplitude of the antenna movement. If the satellite moves only a small amount in 24 hours, the uncertainty of the step track peaks is quite high compared to this amplitude. The ACU compares the movement amplitude to the antenna's (half) 3dB beam width to evaluate this measure. The ACU presents this figure as a percentage value.



The ACU selects the adaptive tracking model following a scheme as illustrated in the diagram above. Below 6 hours data in the tracking memory there is no adaptive tracking possible at all. With at least 6 hours of data and 18 valid samples the ACU uses the SMALL model. If the movement amplitude is above 30% and there are at least 12 hours with 36 valid samples of data available, the ACU uses the MEDIUM model. The LARGE model requires 48 hours of data with 144 valid samples and an amplitude value of 30%. (Beside the recorded hours of steptrack the ACU also watches the number of samples. With a tracking interval of more than 15 minutes, the required times may be longer than shown in the diagram.

The ACU provides a 'max. model' parameter for each axis. You may limit the model size to a smaller one than the ACU would choose by itself. The other way round it is not possible to force the ACU to use a model it has not enough data for.

If the tracking results are bad, the ACU will not be able to calculate a model and set the model to NONE. This occurs also if only one axis have bad tracking results.

Quality information

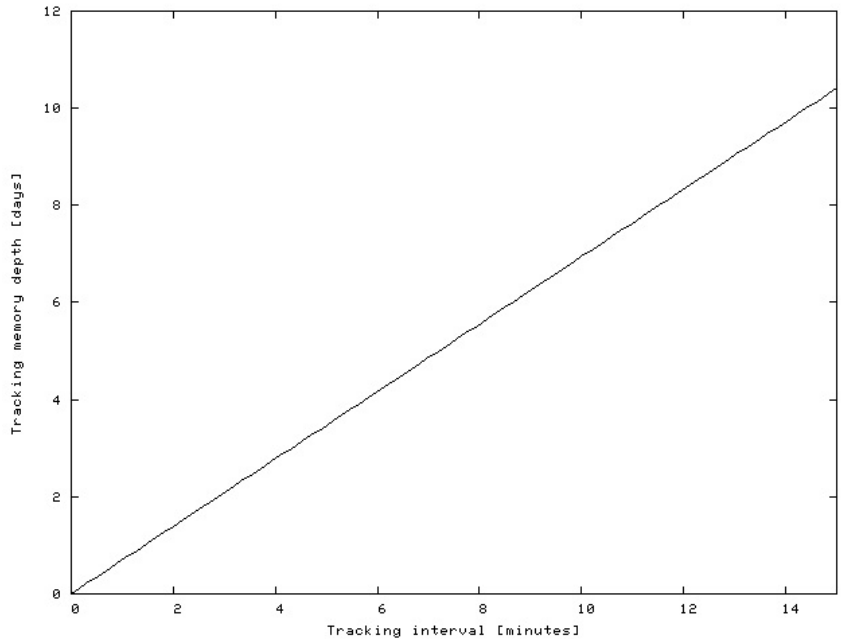
As mentioned above, the amplitude of the satellite's movement is used as a measure of the step track quality. This is because the step track measurement uncertainty is an constant angle which primarily depends on the antenna size.

Beside the amplitude, the ACU evaluates for each axis a figure called jitter. The jitter value describes standard deviation of the measured peak positions with respect to the positions calculated from the model. The figure is also expressed as a percentage of the antenna's beamwidth, low values indicate, that the model ideally describes the antenna's path. High values indicate that's something wrong. The step track results may be to noisy at low amplitudes or the model does not fit at all. This may be the case if a satellite gets repositioned in the orbit.

You may set a threshold value for the jitter. The ACU raises a fault if at least one axis exceeds the threshold value. If this happens three consecutive times, the models gets reset, all data in the tracking memory gets marked invalid.

8.4.2 The Tracking Memory

In the tracking memory the ACU records all steptrack peak positions. The tracking memory is used as a data source for the adaptive tracking and for the smoothing function as well. Each record contains a time stamp, the azimuth / elevation values and the beacon level measured after the peaking. The tracking memory has a fixed size (1000 entries). Once 1000 records are stored, the memory works in a first in - first out manner. How many days of tracking data fits into the memory depends on the tracking interval. The diagram below shows the memory depth vs. the tracking interval.



The tracking memory is volatile, it is erased when the ACU gets reset or switched off. Saving the tracking memory in regular intervals to the ACU's flash memory would damage the flash memory quite quickly.

Memory reset

The contents of the tracking memory must be erased when the ACU starts to track a new satellite. This is done in the following situations:

- A stored position (target) is recalled.
- The ACU is switched off.
- 'CLEAR MEMORY' is chosen at the tracking parameters page.

If a new antenna position is entered by setting the azimuth / elevation angles explicitly, the ACU does not know the new position is a manually optimized one for the current satellite or the position of another satellite. The tracking memory is *not* erased in this situation. If the new position belongs to a new satellite, the tracking memory must be erased manually by clicking to 'CLEAR MEMORY' at the tracking parameters page. Beside this it is recommended to perform a 'CLEAR MEMORY' about half an hour after tracking a satellite starts the first time. This erases the first search steps to the satellite's position and significantly improves the quality of the first adaptive model which will be calculated 6 hours later.

Saving the memory contents

The ACU provides one persistent memory location where the tracking memory may by saved into on an operators request. This may be useful to track another satellite for a couple of hours and then to return to the first satellite. If the tracking memory has been saved before the antenna has been moved to the second satellite, it may be restored after the antenna returned to the old position.

To use this feature, store the ACU settings to the target location 0 (Target memory page). This saves the tracking parameters and the tracking memory as well. When this memory location is recalled later on, the parameters and the memory contents are restored. With this function you should keep in mind, that the tracking memory contents becomes useless after about 24 hours.

8.4.3 Adaptive Tracking Parameters

The behaviour of the adaptive is adjustable with a couple of parameters. First, adaptive tracking also is a step track algorithm. The parameters described in chapter '8.3.4 Steptrack Parameters' therefore apply to the adaptive tracking as well. The parameters concerning the adaptive tracking in particular are discussed in the table below. All parameter described here are to be set at the Tracking page.

AZ Maximum model type **EL Maximum model type**	These settings let you limit the adaptive model to a simpler one, the ACU would choose by itself. The maximum model type can be set individually for each axis. Normally you will set both axes to 'LARGE', which leaves the model selection fully to the ACU's internal selection algorithms. In cases where the ACU seems to be too 'optimistic' about the quality of the step track results, the maximum model on one or both axes may be limited to a more simple and more noise-resistant model. Specially inclined orbit satellites which are located close to the longitude of the antenna's geodetic location may require this limitation for the azimuth axis. With such a satellite, the elevation may move several degrees while the azimuth shows almost no motion.
Level threshold	If the beacon level falls below this threshold value, the ACU does not perform a step track cycle. If the level falls below the threshold during the steptrack cycle, the cycle gets aborted. If the ADAPTIVE tracking is enabled and there is enough data in the tracking memory, the ACU computes a mathematical model from the stored data and predicts the antenna pointing position from the extrapolation of the model. If the tracking mode is set to 'STEP', the ACU leaves the antenna where it is if the beacon level drops below the limit. Adjusting the threshold level that adaptive tracking is switched as expected must be done carefully and may require some iterations, specially if the beacon is received with a low C/N. A good starting value for the threshold is 10 dB below the nominal receive level or 2 dB above the noise floor the beacon receiver sees with a depointed antenna, whatever value is higher. To turn off the monitoring of the beacon level (this in fact inhibits the adaptive tracking), simply set the threshold the a very low value (e.g. -99 dBm)

Peak jitter threshold	If the jitter value of at least one axis exceeds this threshold, the ACU raises an 'model fault'. If this happens three consecutive times, the ACU resets the models of both axes. Adaptive tracking will be possible not until 6 hours after this happens. During adaptive tracking, the ACU evaluates for each axis a figure called jitter. The jitter value describes standard deviation of the measured peak positions with respect to the positions calculated from the (currently selected) model. The figure is also expressed as a percentage of the antenna's beamwidth, low values indicate, that the model ideally describes the antenna's path. High values indicate that's something wrong. The step track results may be to noisy at low amplitudes or the model does not fit at all. This may be the case if a satellite gets repositioned in the orbit. A typical threshold value is 20%, this will detect very early that a model does not fit to describe the satellite's motion. If this value causes false alarms too often, you may want to raise the threshold to 50%. Setting it to 0 switches the threshold monitoring completely off.

8.5 Program Tracking

Program tracking is a tracking method which lets the antenna follow a path which usually has been calculated by an extern software. This software produces a list of time stamp / antenna pointing records. The list is copied to the ACU and the ACU is switched to PROGRAM track mode. The ACU now moves the antenna following the path described in the file. This way of tracking has a couple of advantages:

- There is no beacon receiver needed.
- Even very low elevation satellites may be tracked.
- Also objects which are not in a geostationary orbit may be tracked for a couple of hours, provided that the object of interest does not move to fast.

The main disadvantage of program tracking is that prediction calculations for stationary satellites always are only valid for a couple of days, then a new file must be calculated and loaded to the ACU.

8.5.1 Practical Usage

To use the program tracking facility of the ACU, follow the step by step instructions below:

1. Create a "program.txt" file with the antenna pointings you want to track. SatService GmbH offers a PC Software for this purpose which calculates the antenna pointing from commonly used ephemeris data sets for geostationary satellites. You also may create the file by your own means. The file format is described in chapter '8.5.2 File Format'.
2. Set the 'tracking interval' parameter to a value significantly below the intervals between the position entries in the file. Setting it to 60 seconds will work with most applications.
3. Switch the 'tracking mode' to 'PROGRAM'.

The antenna will move as defined in the "program.txt" file. The ACU polls the file every 'tracking interval' seconds and moves the antenna if it finds a table entry which is time stamped within the next 'tracking interval'. Be aware, that the clock in the ACU must be set precisely to make the feature work as expected.

8.5.2 File Format

The "program.txt" file is a plain text file containing a three or four column table. Empty lines are ignored, comments starting with a '#' as well. The numbers in the table are parsed as floating point numbers which only may consist of decimal digits, one decimal point ans an optional leading '-' if negative. The columns must be separated by an arbitrary number of space or tabulator characters. They have the following meanings:

1	time stamp	The time stamp must be a Julian date with the time of day coded as a fraction of a day. Example: The Julian date for the common base of most computer clocks (1970-01-01 00:00:00) is 2440587.5

2	azimuth angle	The azimuth angle in degrees
3	elevation angle	The elevation angle in degrees
4	polarization angle	The polarization angle in degrees. This column is optional, no polarization pointing is commanded if this column is missing.

Memory space is very limited in the ACU-ODM. The file size is limited to 64 Kbytes, being equivalent to about 12 days of AZ/EL data in 10 minutes intervals.

8.6 Faults and Tracking

There are different faults which could occur during operation. Please also refer to chapter Operation. Below is a collection of all this faults.

There are the following cases for a fault of one axis. 'TIMEOUT' and 'FAULT' are releasable during a tracking cycle. A 'STOPPED' fault have to be released with the RESET button:

- Jump Values of angle encoder; 5° in azimuth and elevation or 10° in polarisation ('STOPPED')
- Antenna moves 5sec into the wrong position ('STOPPED')
- Motor timeout occur because of no antenna movement within the entered time ('TIMEOUT')
- Motor fault input triggered for example from frequency converter ('FAULT')

There are the following cases for a 'STOPPED' fault of all axes together, which have to be released with the RESET button:

- Trigger emergency stop input
- Click the STOP button on the web interface

All faults are released by clicking the RESET button on the web interface or by sending the remote command mrst=0. The RESET button activates the 'MOTOR RESET' outputs of all three axes for a quarter second and delete the fault flags. All target angles are set to the actual value to suppress an immediate movement of the antenna.

If a 'TIMEOUT' or 'FAULT' occur during a tracking cycle in one axis and the cycle is canceled, the ACU will retry after 2min again according to the setting of 'Retry after motor fault' (NEVER/ONCE/FOREVER). The retry is a RESET which activates the 'MOTOR RESET' outputs of all three axes for a quarter second and delete the fault flags. All target angles are set to the actual value to suppress an immediate movement of the antenna. This is also valid for tracking faults like a 'PEAKING FAULT'.

If a fault stay active in one axis and don't disappear during a RESET, the tracking stops the operation. For example if the polarisation have a fault, azimuth and elevation stop the tracking operation.%%

9 Specifications

Technical Specification

Position Encoding with three different interfaces via daughter boards	Resolver, digital SSI and potentiometer
Quantization Error	Resolver 16bit: 0.0055°, SSI 13bit 0.044°, 16bit 0.0055°, 17bit 0.0028°, 19bit 0.0007°
Display Position resolution	0.001°
Interface to beacon receivers selectable	sat-nms LBRX or analog voltage input
Analog voltage input	0 to 10V
Option Tracking Accuracy	Better than 5% of receive 3dB beamwidth (RMS). The encoder coupling and alignment error should not exceed 0.003° to achieve the specified tracking accuracy. The influence of antenna structure thermal error is not considered.
System Interfaces	All interfaces via Mini Combicon MCV1,5/XX-G-3,5
to M&C and ACU-IDU	Ethernet or RS232
to 6 drive limit switches	Azimuth, Elevation and Polarization
Interlock and motors off switches	
3 angular detectors	
Motor driver interface for frequency inverter, DC servos etc.	Via opto coupler input and output, low and high speed selectable

M&C Interface Specification

Ethernet interface for M&C and user interface	10-Base-T, Via http GET requests
RS232/RS422 M&C Interface	Mini Combicon MCV1
Summary fault indication	Relay contact Mini Combicon MCV1

Electrical and Mechanical Specification, Environmental Conditions

Supply Voltage	22V to 28V unregulated DC 500mA
Temperature range Humidity	5° to 40° C up to 90% non condensation
DIN rail module	425x105x60mm